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ABSTRACT

A technology assessment of personal computers was conducted to study both the socially desirable and undesirable impacts of this new technology in three main areas: education, employment, and international trade. Information gleaned from this study was then used to generate suggestions for public policy options which could influence these impacts. Four primary methods were used to develop the information for the policy analysis stages of the assessment: (1) search and analysis of the relevant literature, (2) development of a series of scenarios of alternative futures, (3) performance of two Delphi surveys and a cross-impact analysis based on these scenarios, and (4) interviews and/or surveys of the potentially affected stakeholders and decision makers. Tables of data are included as well as a list of references. Appendices include Delphi questionnaires with summaries of findings and an employment questionnaire used in the study. (LLS)

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A TECHNOLOGY ASSESSMENT OF PERSONAL COMPUTERS: VOLUME III PERSONAL COMPUTER IMPACTS AND POLICY ISSUES

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Preface

This set of reports is the last in a series covering the first two years of progress of the Personal Computer Assessment Project at the University of Southern California. The Principal Investigator of the project is Jack M. Nilles, Director, Interdisciplinary Programs. Organizationally, the Office of Interdisciplinary Programs is a unit of the Office of the Executive Vice President of USC. A technology assessment is a complex, broad-scope activity. As such, it requires the participation of researchers from a number of disciplines and the cooperation of a variety of experts from outside the university. The purpose of the Office of Interdisciplinary Programs is to develop such projects on a university-wide basis.

The USC research team has included the following individuals:

Jack M. Nilles — Director, Interdisciplinary Programs, Office of the Executive Vice President (Project Director; Impact and Policy Analysis; Reports Editor)

F. Roy Carlson, Jr. — Assistant Dean, School of Engineering, Director, Engineering Computer Lab (Technology Forecast; Scenario Development; Education Policy Analysis)

Herb Dordick — Director, Center for Telecommunications Policy Research, Annenberg School of Communications (Telecommunications Policy)

Paul Gray — Professor, Decision Sciences [Now Chairman, Management Science and Computers, Cox School of Business, Southern Methodist University] (Scenario Development; Impact Analyses)

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Michael J. White — Associate Professor, Public Administration (Policy Methodology; Employment Policy)

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Charles Steinfield (Delphi Survey Analysis)
Patricia Walters (Scenario Development, Education Policy)

In addition to the project staff, we have been given much valuable assistance and advice from a Board of Advisors. The composition of the Board has been as follows:

Robert W. Barmeier — Director, Planning Research, Sears, Roebuck Company

Alfred Bork — Professor, Department of Physics, University of California, Irvine

John Craig — Publisher, InfoWorld

Robert Daly — Special Assistant to the Director, Office of Technology Assessment, U.S. Congress

Edward E. Faber — President, Computerland Corporation

Portia Isaacson — Research Fellow, Electronic Data Systems

Hank Koehn — Vice President, Futures Research, Security Pacific National Bank

Ryal R. Poppa — President, PERTEC Computer Corp.

John Ratliff — Consultant

R. B. Shirey — Vice President, General Telephone Company

We have also been fortunate to enlist the cooperation of a number of experts in various aspects of our research by means of our Delphi surveys. The Delphi panelists and our advisors contributed their time, interest and insights far beyond the call of duty. We are grateful for the time spent by those who participated in the surveys associated with the project.

Finally, we are greatly indebted to Dr. G. Patrick Johnson, of the National Science Foundation, for his interest, advice, and encouragement. Although many improvements in our research have resulted from the contributions of these advisors, panelists, and respondents, any failings must remain the responsibility of the research team. Readers interested in gaining further information may contact:

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CHAPTER 1:
INTRODUCTION

The formal art of technology assessment (TA) is relatively recent, the term having been coined only a few years ago. It springs from the broadening recognition by many citizens in technological societies, and by public policy makers in particular, that developing technologies can have unforeseen and, frequently, undesirable and massive consequences. The fundamental goal of a technology assessment is to somehow anticipate both the socially desireable and undesireable impacts of a developing technology, estimate the extent to which public policy decisons might be able to influence the impacts, and to suggest policy options accordingly. The TA is an advisory process. Its findings, if successful, help decisonmakers in direct proportion to the extent to which they minimize surprises in the decisionmaking process.

The purpose of this volume of the Personal Computer Technology Assessment is to present some of the policy issues and options which may arise as a consequence of the development of personal computer technology. Because of limitations of time, funds, and human power not all of the potential issue areas could be examined. A decision was made by the project team at about midpoint in the project, in consultation with various advisors to the project and the National Science Foundation, to restrict the more detailed analyses to a relativelx small number of issue areas. Nevertheless, we hope that the methodology used for these issue area analyses - as described and exemplified in Chapters 3 through 6 of this volume, will provide suitable materials for future analyses of other issues.

In particular, we have attempted here to deal with the realities of the decisionmaking process as much as possible. Policy decisions are not made on the basis of some hypothetical world whose citizens are all well-informed, have a uniformly accepted set of values and goals, and always behave rationally. On the contrary, public policy decisions of any importance are normally made in a welter of conflicting interests, expressed by a variety of individuals and organizational spokespersons, in various settings and situations of process dynamics, and often implemented in ways which seem unrelated to the original intent of the decisionmakers. Further, except for a few, mostly trivial, cases the issues cannot be holistically presented in quantitative terms. Tradeoffs must frequently be made between development of formal cost-benefit analyses and more qualitative success criterion evaluations.

The following pages represent our attempt to cope with these various aspects of the decisionmaking process. Most TAs performed to date have dealt with maturing technologies. Ours deals with an emergent one. We have the advantage of examining potential issues before the technological impacts giving rise to them have begun to appear in any great numbers. Consequently, we can look toward anticipation of the development of impacts rather than finding ourselves in the frenzied situation of trying to cope with impacts that may already be getting out of hand. On the other hand, we have the great disadvantage of having almost no historical data on our specific technology which might lend support to some of the conclusions to which we have come or the speculations we have made. We must rely on postulated analogies to other technologies. This is typified by the market forecasts presented in Volume II of this report.

Fortunately, it appears that rough order-of-magnitude estimates are sufficient at this stage of the process. Since major impacts have not yet occurred there is still time to collect more and better information although, as is argued in Chapter 6, we can not be complacent. We hope that, as the art progresses, the results of this and subsequent assessments can be used to

continually refine our ability to predict both technological impacts and practical means for dealing with them.

CHAPTER 2:
THE ISSUE SELECTION AND ANALYSIS PROCESS

1. Relationships With Prior Work.

Personal computer technology, as defined by our project team, is directly related to the broader area of information processing technology, including computers, microelectronics, and telecommunications. Personal computers are also directly related to transportation technologies, because of their ability to augment or alter transportation modal choices, particularly when they are connected to telecommunications networks. A number of studies have been performed in the past concerning the social impacts of these related technologies. Some of them have been formally named technology assessment, others have not. For example, there is a fairly substantial literature on the effects of computers on society. In general, this literature has concentrated on the effects of large computers; typically, those owned and operated by large organizations. While many of the findings of these studies are applicable to the potential impacts of personal computers, we anticipate some impacts which are essentially unique to personal computers. Nevertheless, the policy issue areas presented in these prior studies have formed a starting point for our own considerations.

For the past several years, various members of the USC faculty and staff (in the Office of Interdisciplinary Programs, the Center for Futures Research, and the Center for Communications Policy Research) have been engaged in technology assessments or related analyses dealing with the societal impacts of information technologies. These studies have included:

1. Telecommunications-transportation tradeoffs (telecommuting);
2. Trans-border international data flow;
3. Development of municipal information service technologies;
4. Societal impacts of electronic funds transfer technologies;
5. Societal effects of broadcast media; and
6. Implications of proposed revisions in the Federal Communications Act.
7. Policy implications of Electronic Funds Transfer.

Since the majority of those individuals who performed or participated in these studies have also had a hand in this assessment, we have been able to take advantage of their perspectives.

2. An Overview of Policy Issues Related to Personal Computers.

Although there is a variety of literature on the impacts of computers on society and on related public policy issues, this literature is concentrated for the most part on eight general issue areas. These are as follows:

1. Job displacement. Do computers create more or fewer jobs? Do they change the nature of jobs to be performed? If so, do these changes result in hardships being imposed on certain segments of the labor force? Is there a government role in ameliorating any hardships

created?

2. Privacy. To what extent do computers and, particularly, computer data bases constitute a threat to the invasion of personal privacy? Is this threat, if any , different in scope or in kind in the public and private sectors? How should the public be protected from unwarranted invasions of privacy?

3. The computer as an enhancer of productivity. Do computers change the structure and processes of organizations to which they are introduced? If these changes increase productivity, either directly or indirectly, how can they be enhanced or accelerated? If the changes reduce productivity, how can they be prevented?

4. The computer as a force toward uniformity and stasis. Does introduction of computers create organizational arteriosclerosis? Do computers limit the ability of an organization to adapt to change?

5. Computer misuse. To what extent does misuse of computers (via accident, mis- or dis-information, inappropriate applications, or crime) cause serious, negative societal consequences? To what extent can computer misuse be prevented by policy action?

6. The computer as a force toward class stratification. Does the introduction of computers into society act to intensify class stratification by creating an "information elite?" Are inequities of opportunity produced as a consequence of the uneven distribution of computers and computer "know-how" in society?

7. The effects of the computer on education and cognitive processes. Does the use of computers in education improve the educational process? Under what circumstances? Does the use of computers change the ways we think?

8. Monopoly versus free competition. Do computers and, particularly, computers interconnected via telecommunications act to increase or decrease the scope and/or intensity of competition nationally? Internationally? What effects do computers and telecommunications have on international economics? How do government policy actions alter the national and international market structure?

The arguments presented in discussions of the effects of computers on society and on their related public policy issues tend to be quite polarized. The enthusiastic technologist presents computers as either a major tool for the solution of many of society's contemporary ills or as the means by which society can evolve to outgrow those ills. The more skeptical group, including some computer scientists, suggest that computers to date may have caused considerably more trouble than they have been worth. As an example of this latter group, we offer an excerpt from an article in Science magazine by Joseph Weizenbaum of the Massachusetts Institute of Technology.

> The structure of the typical essay on 'The impact of computers on society' is as follows: First there is an 'on the one hand' statement. It tells all the good things computer have already done for society and often even attempts to argue that the social order would already have collapsed were it not for the 'computer

> revolution.' This is usually followed by an 'on the other hand' caution which tells of certain problems the introduction of computers brings in its wake. The threat posed to individual privacy by large data banks and the danger of large-scale unemployment induced by industrial automation are usually mentioned. Finally, the glorious present and prospective achievements of the computer are applauded, while the dangers alluded to in the second part are shown to be capable of being alleviated by sophisticated technological fixes. The closing paragraph consists of a plea for generous societal support for more and more large-scale, computer research and development. This is usually coupled to the more or less subtle assertion that only computer science, hence only the computer scientist, can guard the world against the admittedly hazardous fallout of applied computer technology.
>
> In fact, the computer has had very considerably less societal impact than the mass media would lead us to believe. Certainly, there are enterprises like space travel that could not have been undertaken without computers. Certainly the computer industry, and with it the computer education industry, has grown to enormous proportions. But much of the industry is self-serving. It is rather like an island economy in which the natives make a living by taking in each other's laundry. The part that is not self serving is largely supported by government agencies and other gigantic enterprises that know the value of everything but the price of nothing, that is, that know the short-range utility of computer systems but have no idea of their ultimate social cost. In any case, airline reservation systems and computerized hospitals serve only a tiny, largely the most affluent, fraction of society. Such things cannot be said to have an impact on society generally. (Weizenbaum, 1972)

The eight areas of societal impact of computers listed above constitute but one way of arranging statements of the impacts of computers into relatively manageable groups. Personal computers can be expected to have societal impacts in each of the eight areas listed. Additionally, as personal computers become truly more "personal," adapted to the specific uses of single individuals, they may cause changes in both the intensity and nature of their impact on society which could be significantly different from comparable impacts of large computers. Fundamentally the issue is whether personal computers will cause us to 1) "take in each other's laundry," that is to increase useless activity, at an expanding rate, 2) increase the options for, and likelihood of, survival of humanity, 3) neither of the above, or 4) all of the above.

Unfortunately, since the formal study of the impacts of computers on society is relatively new, there are few organized collections of historical data concerning specific cause and effect relationships between the introduction of computers and the appearance of specific social phenomena. Consequently, discussions of the effects of computers on society tend to be anecdotal and broadly philosophical. Neither the reports Weizenbaum disparages, nor many of his own comments on the societal impacts of computers are supported by objective measurements. There are not good statistics on the impact of computers on job displacement, on crime, on equity, or on cognition. There are data on international trade and computer technology, but not on the effects of this trade or technology transfer on changes in international competitiveness. Volumes have been written on the effects of computers, particularly computer-assisted instruction technologies, on education.

Members of our research team point out that a report on the effectiveness of CAI can be found to support essentially any position one might wish to take. Worse, this situation is not due to negligence or incompetence on the part of of those performing the research, but to the fact that we have not yet developed methods for measuring these subtle, complex phenomena.

All of this presents perishingly little comfort to the harrassed policy analyst, who is importuned to come up with specific recommendations in response to these frequently ill-defined, ephemeral and unstable issues.

3. Analysis Methodology and Criteria for Issue Selection.

As mentioned earlier, the research team was faced with the objective of explicating and analyzing these issues under constraints of limited time and budget. Consequently, we developed a general framework which was designed to encourage the screening out of specific issues from the large set implied by the list of impact areas given earlier. Our focus was on bounding the issue areas and sharpening their definition as they would relate specifically to personal computer technology. In this way the number of issues to be given detailed analysis would be winnowed to the set we finally chose.

At the same time, we did not wish to constrain ourselves to issues which had already been reported from within the existing literature oriented to personal computers. Consequently, we began the analysis from the perspective of a broader framework of policy goals and orientations. In the context of these broad goals, we looked for specific possible impacts of personal computers. The elements of the framework and the criteria used for screening potential issues were as follows:

3.1. National Goals and Policy Orientations.

Table 2-1 provides a list of national goals, policy areas, or policy orientations. Some are explicitly legislated goals, some are simply areas in which various policy issues seem to cluster, and some are inferences from observation. Each item in the list was examined to see if PCs might have impacts relevant to it. The list may not be exhaustive, and the items might well be regrouped in different ways by other analysts. The purpose here was simply to take a broad sweep among Federal policy concerns to see if there might be PC impacts that we might otherwise neglect. This list was reviewed weekly by the research team during the early portions of the analysis process.

3.2. Preliminary Issue Areas.

The second step involved the selection of preliminary issue areas for further analysis based on criteria such as: was this a PC issue specifically or an issue of electronic computers in general? Were there sufficient impacts here uniquely ascribable to PCs? Was the issue tractable for analysis? Were data available to allow analysis? Was the issue focused enough for further inquiry or was it too vague? A set of preliminary issues is summarized in Table 2-2. This table also shows conclusions from subsequent steps (and prior research tasks).

Screening Criteria

Uniqueness to (or of) PCs (+); magnitude of impact (+/-); extant agency interest and/or statutory responsibilities; potential institutional agendaviablility; analytical tractability.

TABLE 2-1

National Goals and Policy Orientations

ITEM	POSSIBLE PC ISSUES
Civil Liberties and Individual Diversity	Privacy; Homogenization
Equality of Income	Computer-induced Stratification
Equality of Opportunity	Computer-induced Stratification; computer literacy
Industrial Organization, including market planning and competitive structure, patent/copyright, productivity, innovation, in or through	Competitive considerations in the PC market; Standards; software protection, Dissemination, Venture capital
Economic Stabilization	Foreign trade -- Balance of payment considerations; International penetration of American market and production; Job Displacement
Environmental Protection	
Regional Planning and Governance	
National Defense	
Manpower Policy	Job Displacement; Job Relocation; Retraining; Quality of Work life; PCs in job training
Housing	
Public Health	Some specific software matters relating to accidents, bad advice
Crime	White-collar crime -- use of PCs for theft, etc.
Food	
Consumer Protection	Variety of software considerations; compatability standards
Energy	
Maximum Feasible Social Participation and Personal Realization	Use of PCs by handicapped and developmentally disabled; by learning disabled; use of PCs in education (PCs in Telecommuting)
Transportation	
Telecommunications	

Screening Criteria: Do identified issues fit any recognizable Federal policy priority? Can a Federal policy priority be articulated for a given issue?

SOCIETAL EFFECT/ POLICY ISSUE AREA	"CLASSIC" COMPUTER ROLE	PC ROLE*	MAGNITUDE OF PC EFFECT
JOB DISPLACEMENT	Conjecture in 1960: Elimination of clerical jobs, including unemployment. Actual data to present: Net creation of new jobs.	PC if widely diffused may result in net loss. Plus shift in entertainment, industry, education, creation of jobs for handicapped.	Proportional to log(No. of units) Positive Most likely more jobs created than lost. Negative Greatest near-term eff. on older, computer illiterate workers.
PRIVACY	Improper access to, aggregation of, information on personal affairs.	←Plus invasion of right to solitude; when used as screen, may tend to counteract invasion of privacy.	Proportional to log(No. of units) Negative Used by business, govt; compounded by networking of data bases. Positive Prop. to use as screen, use of encryption devices.
COMPUTER AS CHANGE AGENT -- Organization Structure	Introduce new management tech. to large orgs. Aid in accelerating technological progress. May decrease decision making flexibility (or possibility) of mid management.	←Plus introduce mgmt. tech. to small org. Can provide more flexibility to middle management. May act to counter org. paralysis in large org. via PC "guerrillas."	Proportional to log(No. of units) (?) Can make significant diff. to viability of small business. Use by middle mgmt. may accelerate trend toward office automation - corresp increase in "white collar" productivity, effects on JOB DISPLACEMENT.
COMPUTER AS HOMOGENIZER	Standard software produces standard organization, people.	←But Dehomogenizer (chaos producer; wavemaker (?)) in some cases (See PERSONAL FREEDOM).	Proportional to log(No. of units) Accelerated homogen. in some areas (business&finan. sys) May allow dehomogen. in others. (See CHANGE AGENT, PERSONAL FREEDOM)
MISUSE - ACCIDENTS	GIGO, inappropirate, sensitive to clerical errors.	Higher sensitivity to accidents unless better software than large comp.	Exponential. Mistakes of early stages of growth of large comp. may be repeated; eff. of "virus" progs, etc. - more widespread.
- CRIME	Theft of computer time, funds.	←Plus Theft of PCs. Use of PCs as burglary tool, wiretapping (See PRIVACY).	GEN Prop. to No. of units. However, may increase prod. of organized crime ———→exponential

TABLE 2-2

SOCIETAL EFFECT/ POLICY ISSUE AREA	"CLASSIC" COMPUTER ROLE	PC ROLE*	MAGNITUDE OF PC EFFECT
CLASS STRATIFICATION	Slight trend toward computer elitism.	Could cause "information disadvantaged."	Proportional to distribution of PC ownership among eco. classes X step discontinous functions (i.e., may be large effect for some people).
EDUCATION, COGNITION	Little widespread impact (mostly due to high cost, low CAI effectiveness), except administrative DP.	Reduction of administrative time load of teachers; low cost CAI; threat to "education establishment." Mechanization or liberation of thought processes (?)	Proportional to(No. of units in ed. system)+(No. of units)*(CAI software effect in home) CAI effect highly dependent on software quality. --no data available on cognitive impacts
EXPANSION OF PERSONAL		Possible major influence in bringing	
— CAPABILITY	— Small, except in change agent role.	— Vocational, avocational expertise to individual.	Proportional to: scope, quality of software, # of units, demographic distrib.
— FREEDOM	— Little effect	— Can materially increase options avail. to individual, especially as electronic mag services become available.	Could be major factor in devel. of T^3 new info. "cottage" industry; affect 50% of labor force.
FOREIGN TRADE	Large computers constitute X of net U.S. positive balance of payments in 197	Consequences depend on relative competitiveness of US, foreign industries (esp. Japan, England). If US stays ahead, increased pos. bal., if for. countries take over US market, then negative balance.	Proportional to K (Net No. of units ex(im)ported), where K > 1.

TABLE 2-2 (Cont'd)

* ← Means "same as large computer systems"

3.3. Technological Forecast.

In this stage, our previous technology forecasts were examined and, if necessary, revised and/or expanded to answer the following questions for the issues selected in step 2. What technology was currently available that would cause a problem or opportunity to exist? ("Problem" implied a plausibly undesireable incongruence with existing policy or widely held values. "Opportunity" implied a possible technological means of ameliorating a previously identified problem.) What technology might become available, and when, which would mitigate the problem, aggravate it or create a new problem or opportunity in this area? Who might develop this technology; at what cost? What likely private and governmental actions might retard or accelerate these developments? What indices could be monitored here?

Screening Criteria

The technology needed to make the problem serious is unlikely to become available during the study's time horizon (+); or, the technology needed to make the problem disappear is likely to become available within the study's time horizon and without Federal intervention before the problem becomes serious (-). Criteria for "likelihood" estimates are qualified by the severity of the problem being considered.

3.4. Market Forecasts.

In this stage, the technology forecasts were augmented by reference to our market forecasts and those of others. What was the (order of magnitude) size of the market relevant to this issue under study? What relation was there between market size and the impact of concern? What were the growth rates of markets? Who was in the market (producers and consumers)? How might applications develop to affect this issue? What characteristics of society were relevant to the market here (e.g., computer literacy)? What market events and trends would aggravate or mitigate the problem? Transform the problem? What indices could be monitored?

Screening Criteria

Did the market forecasts indicate that a sufficient number of people, or a critically located group of people, would likely be at risk (or have an opportunity for risk mitigation) for the problem indentified? Would the market be large enough for a problem to exist?

3.5. Impacts.

Given the technology and market forecast (note that fairly gross measures of market size are adequate for most aspects of the analysis), what were the most likely impacts, who would be affected, in what numbers, and to what extent? Scope and severity of impact ratings were developed. The shape of the functional relation between market size or technological capability, on the one hand, and social impact, on the other, were conjectured as well. A Delphi study was used as a major element of this analysis, preceded and augmented by more detailed impact analyses by the project team. Issues of less than major impact were screened out here.

Screening Criteria.

Number of people suffering loss or reaping benefits; direct economic impact; magnitude of impact on individuals; structural impact on market development; foregone or realized opportunities.

3.6. Existence of Self-Organizing Responses.

Issues may be resolved by the operations of non-governmental, or at least, non-Federal institutions. In order to clearly exclude issues for which a Federal response might clearly be superfluous, the impact assessment was supplemented by an appraisal of likely private and non-Federal governmental responses. Two types of responses are possible: decentralized and quasi-centralized. Local government codes and private market participation are examples of the former. Private standards agencies are an example of the latter.

Important here was the specification of monitoring criteria for the identification of response failures in the non-Federal sector regarding issues with sizable impact.

Screening Criteria

Is it likely that private responses will eliminate any need for Federal response, adjusted for a consideration of the magnitude of impact in the event of private failure? Thus, for key, large-potential-magnitude impact areas, a high (but less than unity) probability of a successful private response might not exclude the issue from further consideration.

3.7. Federal Interests.

Even if the issue is likely to be handled privately, there remains a need for the specification of Federal interests in any issue with major impact. This specification includes institutional (agency) responsibilities and statutory authority. But, it also needs a process dimension as well. We sought here to assess whether an issue had "agendaviability," or whether, regardless of the size of the impact and the likely private response (or lack thereof), the issue were viable as a political issue. Some issues may not be likely to occasion governmental resolution; for example, the Federal responsibilities may be too diffuse, dispersed, or conflicted. There is no point, at least at this stage of the assessment, in analyzing in detail issues unlikely to occasion any effective response. Here, also, the areas in which the interest may be expressed also were considered. These included, besides specific institutional domains, the various courts, the Congress, the regulatory agencies, and the agency rules and CFR regulations outside of the independent regulatory agenices. It was at this stage also that the kinds of institutional interests discussed in Appendix B were considered, e.g., agency interests in domain protection, legitimacy, deterrence capability of its enforcement activities, maintenance of decision latitude, etc.

3.8. Political Factors.

Here, the political process variable was addressed. These included: who were the stakeholders and what were their interests (political and economic)? What public interests and principles were involved? What were the tradeoffs inherent in the issue? What decision chains and processes were

appropriate and likely here? Whose participation and attention was essential or helpful or obstructive? What was the latitude for decision? What externalities might there be that would expand the scope of the conflict? What legal instrumentalities might be chosen here, and who was needed to make them work?

3.9. Appraisal Factors

How would it be known that the problem is resolved? What were the criteria for terminating or revising any Federal intervention? What indices of the need for policy change could be institutionalized? What were the foreseeable countermeasures which might be monitored? What technological and market changes would require a policy modification?

These nine stages are in addition to the standard policy analysis phases intermingled in stages 7 through 9 in which specific, issue-limited goals and objectives are set, situations modeled, options examined and sensitivity tested, assumptions detailed, etc.

This nine stage process was not followed in rigorous, sequential order; rather in practice it was iterative. For example, the political analysis of step 8 might occasion a return to the market analysis of step 4 for further investigation, and so on. Furthermore, the results of some of the steps are often more implicit than explicit in the results of the research as reported in later chapters.

4. An Example: Personal Computers and RF Interference.

The following is a brief description of the existing and potential circumstances surrounding one recently resolved policy issue related to personal computers, deriving from the fact that personal computers can emit radio frequency signals which can interfere with nearby television sets.

Market Action

A number of manufacturers of personal computers, in an attempt to minimize the apparent market price of their offerings, elected not to include a cathode ray tube display as part of their system; instead, they provided a video output device which would allow the PC owner to use that video output to drive his/her commercial television set.

The problem with a number of these converters, some of them PC-manufacturer-supplied, others available from other manufacturers, and with some of the pesonal computers themselves, was that they "leaked" their signals at sufficiently high levels to interfere with nearby television sets, such as in a house or apartment building. This problem also occured with video games and similar devices, which could be considered to be primordial personal computers. Present FCC rules require certification of these "restricted radiation devices."

The two PC manufacturers having the dominant market share in 1979, Tandy Corporation (Radio Shack) and Apple Computer Inc., either required an external modulator which was left to the PC owner to supply or offered an optional display device to be hard-wired to the computer. Texas Instruments, Inc., because of a presumed desire to enter the low-price end of the PC market in mid-1979, filed a petition with the FCC, asking that the Commission establish new, relaxed standards for modulators. This would allow them to market a low-cost computer system, using a consumer's television set as a

display, without going through the FCC testing required by present standards. The FCC rejected the petition and Texas Instruments has subsequently introduced a small computer system which is priced at about the same level as the Apple system, but higher than the system offered by Tandy Corporation (i.e, about $1200 for the TI or Apple systems, half that for the minimum-size Radio Shack system).

It is not yet clear whether the higher price of the TI system with the required hard-wired video monitor will affect sales in their primary target market: home use. However, the FCC decision has clearly had an impact on the market structure.

Our market and technology research led us to the following conclusions (in mid-1979):

> First, there are no technological barriers to development of a low-cost, interference-free RF modulator suitable for PC and video game use. Therefore, if the demand is seen as sufficient, firms will develop and manufacture certifiable modulators and go through the certification process.
>
> Second, the market for PCs in the home is presently highly price sensitive, one reason that many manufacturers are now concentrating on the business, rather than the home market. Nevertheless, we forecast that the home market in 1982 will be in the order of 750,000 units, for an annual gross sales of about $250 million, assuming the PCs are modulator-equipped. If hard-wired monitors were to be required for these systems, the unit price would increase by at least $100 to $300, a substantial fraction of the total price. The result could be a significant reduction in the size of the market although there were no data available at that time concerning the demand elasticity of the consumer computer market.

Identification of Issues

Constitutional Issues

The most apparent issue at this point stems from the constitutional rights of free speech and freedom of the press, as embodied in the FCC's rule regulating RF interference. In this case, the FCC is acting as the protector of the public interest by requiring that PCs, video games, and the like not interfere with commercial or other forms of broadcasting (CBs, ham radios, etc.). The direct effect of the refusal of Texas Instruments' petition served this end.

Free Market Competition

One indirect effect is that the FCC's position alters the nature of the competition in the marketplace. Texas Instruments has possibly become less competitive to the aforementioned and other manufacturers as a consequence of this decision. Nevertheless, the mangagement of Texas Instruments has apparently decided that their initial loss in competitiveness, if any, will be compensated by their earlier entry into the marketplace (i.e, earlier than they would have been able to enter had they gone through the modulator certification process).

One can make an interesting contrast here between the apparent competitive strategies of Apple Computer, Inc. and Texas Instruments, Inc. Apple seems to have adopted the strategy of encouraging a diverse number of

technological entrepreneurs to produce hardware and software which is compatible with the basic Apple II system. This strategy appears to be quite successful so far and generally acts to encourage free competition in the industry (although it raises accompanying issues of protection of software copyright and development of uniform standards). Texas Instruments, on the other hand, emphasizes the use of read-only memories as the embodiment of the major portion of the applications software for their newly introduced system. This follows their prior strategy with programmable calculators. The user of the Texas Instruments' computer has relatively little "free" memory to use for his/her own programs or those developed by other than TI. The critical economic point here is that a read-only memory module, such as that required by TI, involves a much higher initial capital investment for its production than does software which is transferrable to magnetic cassette or disk. Hence, the architectural approach used by TI in the design of their computer embodies significant potential restrictions on competition for TI-compatible accessories, particularly for small firms. To what extent is it in the national interest to encourage competition in this area? Should the Apple approach be given preferential policy treatment over the TI approach and, if so, by whom and by what means?

[Note: the issue of competiton versus free market action, as typified by the case above, was not ultimately selected as a topic for detailed investigation in our research. Subsequent to the analysis given above slightly relaxed rules were allowed by the FCC. All personal computers sold today must comply with these rules.]

The FCC also is actively encouraging increased competition in the information industry, primarily by disallowing restrictions by communications carriers on the use of their services. (Note: remarks of Dr. Jefrey A. Krause, Assistant Chief, Office of Plans and Policy, Federal Communications Commission before the Morgan Stanley Personal Computer Forum, New Orleans, LA, May 3, 1979.) A primary mechanism by which competition in other than the communications industry could be increased through FCC decisions relates to the use of personal computers as receivers or providers of information services over telecommunications networks. Here two FCC decisions related to technology could affect competition. The first would be the granting of FCC approval to one or more RF modulator devices which could be used effectively with a variety of low-priced personal computer and home television sets. The second would be a similar FCC approval of low-cost modems for interconnecting personal computers with each other and with larger computers through telephone lines (current costs to a personal computer user for a modem range from $150 for a "dumb" device to almost $500 for a sophisticated system allowing automatic dial-up and answer). If these costs to the user could be reduced by an order of magnitude, significant incentives for telecommunications interconnect would develop. In both cases, the question is whether the FCC will take an active or passive role in encouraging, or even requiring, the production of such low-cost devices which would nevertheless meet national standards. Potential secondary effects of this action are discussed in Volume II.

Stakeholders

The immediate stakeholders in the RF interference case are, of course, the Federal Communications Commission and the prospective RF-interfered-with public it seeks to protect, Texas Instruments, Inc., distributors and retailers of PCs and modulators and other manufacturers of personal computers or of related RF modulators, both domestic and foreign. These stakeholders, with the possible exception of some small entrepreneurs and the general

public, are already aware of their interests. Stakeholders who are less directly affected (and are less aware) include the telecommunications industry, the Department of Commerce (Economic Development Administration, Bureau of Standards, Patent Office), Small Business Administration, Federal Trade Commission, state and local regulatory agencies (for example, the City of Los Angeles now requires that personal computers sold within its limits conform to FCC standards, where applicable, and be certified by Underwriter's Laboratories). The next level of indirect impact is, of course, those organizations and individuals affected in other ways by the use (or inaccessibility) of personal computers.

Instrumentalities

Figure 2-1 includes entries relevant to the RF interference issue. Most of these instrumentalities have been implicit in the previous discussion.

5. Tools for Analysis

Four primary methods were used to develop the information for the policy analysis stages described in the preceding sections. These were: search and analysis of the relevant literature, development of a series of scenarios of alternative futures, performance of two Delphi surveys and a cross-impact analysis based on these scenarios, and interviews and/or surveys of the potentially affected stakeholders and decision-makers.

Literature Evaluation

Because of the variety of potential societal impacts related to widespread use of personal computers, and because of the high rate of change of the underlying technologies, a major component of the project was the continual search and evaluation of relevant literature. This search involved analysis of the traditional books and journal articles written on economic, social, political, and technological factors, augmented by a continuing review of articles in the popular press and trade journals.

Scenario Development

A common and useful strategem for focusing the acquired background information is the development of a series of scenarios depicting the potential uses of the technology in question. Each scenario is written to depict a realistic scene or sequence of events centered about a major potential application of the technology. The fundamental objective of an individual scenario is to provide a basis for development of a multi-dimensional matrix showing the interrelationships between the technological factors, direct and indirect impacts.

The immediate use of the scenarios developed during the research was to provide the basis for the questions asked in the subsequent Delphi surveys and actor/stakeholder interviews. Each scenario used went through an evolutionary process in which it was modified and refined either to match most likely perceived trends or to clarify certain areas where there appeared to be high uncertainty in the potential course of events. The initial collections of scenarios were presented at each of the meetings of the Advisory Board, for example, so that the research team could gain the benefit of the advisors' experience in those areas in which they had special competence and expertise.

MODE OF INTERVENTION		INSTRUMENTALITY (I) Direct Federal Expenditures & Procurements Including Contingent Expenditures & Forgone Revenues	(II) Federal Policy Issues	(III) Federal Mandates Other Levels Of Government or Private Government	(IV) State and Local Policies	(V) Private "Governments" Such as Professional Associations and Standard Bodies
A	Constitutional Prohibitions and entitlements					
B	Common law protections and obligations					
C	Judicial proceedings	X				
D	Licensing	X			X	
E	Promulgated standards and specifications	X				X
F	R & D (Support or performance)	X				
G	Risk absorption, e.g., tort relief, regulatory exemption, [illegible] guaranty	X				
H	Tax subsidy					
I	Property protection (patent, copyright)					
J	Direct support of diffusion by subsidy, training					
K	Direct operation, or production, for the market or as a "yardstick"					
L	Mandated service standard and financially contingent standards					
M	Technical assistance programs, e.g., Ag. Ext.					
N	Direct procurement					
O	Mandated procurement					
P	Demonstrated projects and subsidized applications					
Q	Sponsorship of information exchange					
R	Maintenance of information resources					
S	Direct collection and/or publication of data, or requirement and/or sponsorship of same					
T	Inspection/Certification	X				X
U	ENFORCEMENT	X			X	

FIGURE 2-1

PERSONAL COMPUTERS and RF INTERFERENCE

Delphi Surveys and Cross Impact Analysis

The Delphi technique is a method for obtaining a consensus of opinion from a panel of experts that avoids the "jury room" effect typical of face-to-face discussions. A panel of experts is presented with a questionnaire which asks them to respond, individually and preferably in quantitative terms, to a series of questions about which information is sought. The responses to this initial questionnaire are collated and results are fed back to the panelists. The panelists are then asked to review their previous estimates in the light of the distribution of responses of their colleagues. They are also asked to state their reasons for their estimates, particularly if these are near one or the other end of the distribution of panel responses. This process is repeated until the spread of opinion among panelists is substantially reduced. The median of the last round of the estimates is accepted as the baseline forecast developed by the expert panel. These forecasts are "baseline" in the sense that they are based on "all other things being equal;" that is, they are the expected values anticipated.

The anonymous debate generated in the Delphi technique reduces the influence of psychological factors, such as specious persuasion, the unwillingness to abandon publicly expressed judgments, the bandwagon effects of majority opinion. The Delphi process has proved particularly valuable in capturing expert opinion about the nature and likelihood of future events and trends.

Although, in our initial project plan, we estimated that three Delphi rounds would be required to develop the necessary convergence, we achieved that convergence after only two rounds, plus a "round 0" study which was confined to the project's Advisory Board. The content of these surveys and the results are described in Chapter 3.

In long-range planning it is necessary to take into account not only the effects of individual developments, but also the effects of the interactions among developments. Cross impact analysis is a systematic method for dealing with such interactions in long-range planning. In using the cross impact approach a planner, before deciding on a policy in an associated action program, first lists the most important potential future developments that are relevant. Such developments generally include both:

A. Events (that is, technological break-throughs and new legislation), and

B. Trends (for example, inflation, changes in demand for services, changes in spendable income).

For each event, the planner obtains baseline forecasts of the probable time at which the event will occur and estimates of the effects which the event will have on each of the other developments when it occurs. This events and trends information was elicited from our panel of experts as a part of the Delphi analyses. The results of the cross impact analysis are also presented in Chapter 3.

Interviews with Actors/Stakeholders

A conspicuous characteristic of an assessment of a technology which is in its infancy is that there are no real "experts," that is individuals who have long experience in the subject field. This is particularly true in those areas outside the technology itself, where the impacts have yet to be felt or

its possibilities widely perceived. Consequently, the final technique used by the research team to augment the information gathered by the other methods just listed was to conduct a series of telephone or face-to-face interviews with some of the primary actors and stakeholders identified by the other means listed above. The interviews were more closely akin to investigative reporting rather than the carefully structured approach more typical of well-controlled opinion research. Nevertheless, the interviews were of great utility in refining the course of the policy analyses and of the underlying Delphi and cross impact matrix questionnaires.

In one specific area, that of the potential effects on job displacement of personal computers, a more structured questionnaire was sent to a selected sample of personnel directors in major corporations throughout the United States. This questionnaire had two primary objectives: to determine whether personnel directors in large organizations were concerned, or even thinking about, the effects of automation in information work, and to get estimates of the diversity of opinion concerning the probable effects of microcomputers on office work. The results of this questionnaire are reported in Chapter 5.

References

Weizenbaum, Joseph. "On the Impact of the Computer on Society." Science. Vol.176 May 12, 1972, pp.609-14. Copyright Weizenbaum, 1972.

CHAPTER 3:
IMPACTS

The research team's analysis of the possible patterns for future growth of personal computer technology and the developments of the personal computer market led to a series of questions concerning the details of this growth and of the probable direct and indirect impacts of these developments. The research team investigated the likelihood of a broad array of primary and secondary impacts of personal computer technology. The impact estimates were then used to develop corresponding estimates of their public policy implications.

1. Issue Selection

Two techniques were used to develop these impact estimates. First, information on the primary demographic characteristics of U.S. society and on the likely paths of development of personal computer technology end markets were extrapolated generally to the end of the century. These extrapolations were used to develop a series of scenarios of possible future states of U.S. society which might result from the development of the technology. These general scenarios then divided a series of shorter scenarios dealing with specific, public-policy-related aspects of the development of personal computer technology.

Shortly after the beginning of this period of impact analysis, the research team had categorized the potential impacts of personal computers into 14 areas. These covered the effect of personal computers on:

1. Job Displacement; changes in the nature or existence of employment,

2. Privacy and Security, both individual and institutional,

3. The rate of change of technological innovation, including changes in management and organizational technologies,

4. The level of homogeniety or uniformity of societies using personal computers,

5. Misuse and crime; intended (by perpetrators) and unintended consequences of computer errors, computer fraud, etc.,

6. Class stratification; development of an "information elite", increasing educational and economic gaps between the elites and the information underprivileged (the "haves" and the "have nots"),

7. Education and cognition; this to include such issues as changes in the effectiveness of education, broad scale increases in educational quality, and effects on intuitive and, affective thought processes,

8. Expansion of personal freedom and capability, including expanded choices of vocation and avocation, extensions to the physically handicapped,

9. International trade, particularly impacts on the relative position of the United States in the World market as a consequence of the manufacture and/or use of personal computers,

10. Standards for personal computers, with emphasis on the desirability and consequences of development of various types of standards in a dynamically evolving technological market,

11. Industrial organization, particularly impacts on the relative extent of competition vs. monopolistic practices,

12. Consumer protection, particularly the relative merits of government aids to increasing consumer computer literacy and regulation of personal computer technology,

13. Energy conservation, particularly the potential effects of the use of personal computers on the rate at which individual consumers and organizations would conserve energy, and

14. Health; the potential impacts of personal computer technology on the methods and quality of health care.

Note that this list is not in any order of priority. The impact areas were also examined in terms of any differences which might occur as the consequence of having widespread availability of network information services usable with personal computers.

It was soon clear that within the limited time available for performance of the assessment, not all of these impact areas could be analyzed in detail, consequently, a set of screening criteria was developed in order to reduce the number of impact areas to be investigated. These criteria were the following:

1. **The uniqueness** of the impact and/or policy issues vis-a-vis-personal computer technology; would the impact be unique to personal computers or would the impact of personal computer technology provide unique policy perspectives on impacts or issues deriving from other technologies?

2. **The magnitude** of the impact; would the overall impact of the technology be significant? That is, would large numbers of people be affected or would the effect be economically, politically and/or socially substantial, even if it were to involve a relatively small number of people?

3. **Existing public agency responsibility**; are there identifiable public agencies which presently have, or may have, responsibility for the development and/or implementation of policy concerning the impact area?

4. **Potential agency interest**; furthermore, are the identified agencies at all likely to believe that they have an interest in the impact areas sufficient to pursue available policy options?

5. **Analytical tractability**; is it possible to get a reasonably accurate estimate of the extent or magnitute of the impacts or consequences of public policy actions or are the impacts and action consequences so diffused as to defy measurement by existing techniques?

Through the use of the selection criteria, the research team was quickly able to reduce the list of impact areas from 14 to 7: workforce and employment, international trade, education, privacy, crime, standards, and consumer protection.

At this point, the research team engaged in a series of three Delphi Surveys. [A Delphi Survey is one in which a structured questionnaire covering events, trends, impacts, and policy options, is administered, usually by mail, to a group of experts in the areas covered in such a way that the experts do not meet face-to-face to debate.] The first survey was confined to the Advisory Board for the assessment. The second round went to a panel of 150 experts, 64 of whom responded. We also asked the experts to "vote" on the relative viability of the issue areas, using the screening criteria. As a consequence of this round, and the distribution of expertise of the experts on the panel, we reduced the number of areas for detailed study during the remainder of the research project to three: education, employment, and international trade (see Section 4). In none of these areas is the introduction of personal computer technology likely to have entirely unique consequences; in all of them the analysis of the potential impacts of personal computers provides important perspectives on other technology related issues.

2. Events and Trends

One of the primary uses of the Delphi surveys was to provide balance to our independent analyses and to suggest potential impacts, trends, or areas of investigation which we might otherwise have overlooked.

2.1 Events

The Delphi panel was asked to evaluate the earliest, most likely, and latest time (which might be never) of the occurrence of a number of potential events relevant to the growth in usage of personal computers. Table 3-1 lists the event statements and the short form used to refer to them. Table 3-2 summarizes the panel's opinions on the most likely time of occurrence of these events. The table indicates the mean value of the most likely time of occurrence. It can be seen from Table 3-2 that events can be grouped into near term (1980-84) intermediate term (1985-1990) and long term (beyond 1990 or never).

The following were deemed by the panel to be the most likely to occur in the near term, that is, in the 1980-84 period:

1. A number of new entrants into the PC market. These entrants included:
   - Large retail chains such as Sears or Wards or Federated Department Stores
   - Large mainframe manufacturers (e.g. IBM, Control Data)
   - Non-computer manufactures (e.g. watch, appliance, copier, manufacturers)
   - Major foreign-based corporations marketing complete units under their own names.

2. A commercial firm develops and successfully markets a low-cost computer based network information service specifically for PC's

3. In technology, a 32-bit address register is introduced for PC's by one of the major PC producers

4. Development of various ways of protecting PC software and programs. This may take the form of encryption or hardware or software other than ROM.

TABLE 3-1

INITIAL LIST OF EVENTS

1. Sears: Sears, Macy's Ward's enter PC merket.

2. IPA: IBM, Control Data, Sperry Rand-size company enters the PC market.

3. TIMEX: Major U.S. company not in computer manufacture (e.g., Timex, Westinghouse, Maytag, Xerox) enters PC market.

4. JAPAN: Japanese (or Europeans) enter the PC market in United States (as major competitor?)

5. CB Craze: A CB-like craze for computer entertainment occurs.

6. PC NIS: Commercial firm develops and successfully markets a low-cost computer-based network information service for PCs.

7. PC Viewdata: Establishment of national commercial information retrieval network for PCs such as Viewdata.

8. PC Polling: Establishment of a network of PCs in a community or region capable of polling voters.

9. AT&T: Revision of 1934 Communication Act is passed to permit AT&T to compete in information services industry.

10. 32-bit PC: A 32-bit address register is introduced for PCs by one of the top 4 PC producers.

11. $50 flat screen: Commericialization of a low cost ($50 to produce) flat screen for TV.

12. Dynabook: DynaBook-size and capability PC is introduced.

13. PC Registration: Passage of law requiringregistry of PC ownership just as FCC requires registration of CB radios.

14. Pirateless software: Development of software or hardware other than ROM to make PC software effectively pirate-resistant.

15. Institutional Software protection: Establishment of measures (institutional, organizational, or contractual) that effectively make PC software resistant.

16. Encryption for PCs: First commercialization of "break-proof" encryption module for PCs.

17. Privacy Act applies to PC's: Enactment of Federal legislation that makes home PCs subject to Privacy Act of 1974.

TABLE 3-1 Cont'd

INITIAL LIST OF EVENTS

18. Subsidy for low-income PC use: Establishment of direct government subsidy for PC access for low income people (e.g., through libraries, churches or other public centers).

19. Courseware development: Initial marketing of PC courseware for elementary school instruction by major publisher or computer industry firm.

20. Home monitoring: At least 50% of all homes built in a year for $100,000 or more (1978 prices) include a dedicated PC for complete monitoring.

21. IRS requires Computer reports: IRS requires that income taxes for all businesses with at least $1 million (1979 dollars annual sales be submitted in machine-readable form.

22. 10 Fortune 500's use PC's to substitute for travel: Chronic gasoline shortages cause at least 10 of Fortune 500 companies to set up local work centers using PCs and telecommunicastions for information transfer.

TABLE 3-2
DELPHI PANELISTS' FORECASTS
OF
MOST LIKELY TIME OF OCCURRENCE OF EVENTS

		81-84	85-90	+90	Never
1.	Sears	◘			
2.	IBM	•			
3.	TIMEX	•			
4.	JAPAN	•			
5.	CB Craze		◘		
6.	PC NIS	◘			
7.	PC Viewdata		◘		
8.	PC Polling		•		
9.	AT&T		•		
10.	32-bit PC	•			
11.	$50. flat screen		◘		
12.	Dynabook		•		
13.	PC Registration				•
14.	Pirateless software	←	→		
15.	Insitutional Software protection		•		
16.	Encryption for PC's	•			
17.	Privacy Act applies to PC's			•	
18.	Subsidy for Low-income PC use		•		
19.	Courseware development	◘			
20.	Home monitoring		◘		
21.	IRS requires Computer reports			•	
22.	10 Fortune 500's use PC's to substitute for travel		•		

◘ - Major impact on home market when event occurs

5. In education, the initial marketing of PC courseware for elementary school instruction by a major publisher or computer industry firm.

The intermediate term (1985-90) was presented to be the most likely for the occurrence of the following:

1. A CB-like craze for computer entertainment

2. Additional network information services such as:
- national commercial information retrieval network for PC's equivalent to Viewdata
- a network of PC's in a community or region capable of polling voters

3. Technological developments would include a low cost (less than $50 to produce) flat screen for information display and a Dynabook size and capability for PC's

4. Establishment of institutional, organizational, and contractual measures to protect software

5. Establishment of direct government subsidy for PC access for low income people (e.g., through libraries, churches, and other public centers).

6. At least 50% of all homes built in a year for $100,000 or more (1978 dollars) include a dedicated PC for complete monitoring.

7. Chronic gasoline shortages cause at least 10 of the Fortune 500 companies to set up local work centers using PC's and telecommunications for information transfer

In fact, some of the events had already occurred while the questionnaires were being completed, others shortly after. For example,

- Sears has begun marketing the ATARI computer system

- IBM is offering its 5120 system as a relatively high-priced competitor in the small business market. This computer fits within the definition of personal computers used in this project.

- Mattell toys is offering units that are more than game units (Intellivision) and is promising BASIC shortly.

- Nippon Electric showed various complete personal computer units at the 1980 National computer Conference in Anaheim, CA. However, they were noncommittal as to when or whether these units would be introduced in the United States.

- Tandy Corporation announced a new unit, called Videotex, at the beginning of June 1980. This unit, to be sold at $400 to the commercial market initially, (and anticipated by Tandy to be sold at $200 to consumers later if successful) has a full keyboard and permits inquiry of network information services. It is a successor

to Green Thumb (see below). Compuserve, a Columbus Ohio based time-sharing service simultaneously announced that it would offer dial-up access to its data bases via sales made through Tandy's Radio Shack outlets. The Radio Shack stores would act as sales agents for Micronet, the existing PC network information system currently operated by Compuserve.

- Encryption software for PC's (meeting NBS standards) appears to be available, although not widely used at this time.

- Although some software has been supplied by Tandy for the TRS-80's sold to school districts, the number of units sold thus far is quite small and little specialized software seems to be available.

The panel believed the following events were most likely to occur in the 1985-90 period:

1. A CB-like craze for computer entertainment

2. Additional network information services such as:

- a national commercial information retrieval network for PC's equivalent to Viewdata
- a network of PC's in a community or region capable of polling voters.

3. Technological developments believed five or more years away were a low cost ($ less than $50 to produce) flat screen for information display and a Dynabook size and capability for PC's

4. Protection of software by institutional, organizational and contractual means.

5. Establishment of direct government subsidy for PC access for low income people (e.g., through libraries, churches, and other public centers)

6. PC's for complete monitoring would be included in more than half the homes bult each year for $100,000 or more (in 1978 dollars).

7. At least 10 of the Fortune 500 companies would set up local work centers using PC telecommunications for information transfer. These changes would be one way of coping with chronic gasoline shortages.

Examining the mid term developments, one sees that some (e.g., network information services and software protection) are extensions of near-term developments. Others (e.g., the technological developments and home monitoring) seem to require more time to gestate but are evolutionary. Two of the developments are relatively major departures: government subsidies and communications substitution for transportation. However, even for these developments there are precursors.

Project Green Thumb, alluded to above, is an example of government subsidy to bring information to specific societal groups. In this project,

sponsored by the Department of Agriculture at the University of Kentucky, 200 farmers in two counties in Kentucky were given simple chip-based keyboards which they could use to obtain Viewdata-type information. The Green Thumb box looks like a standard touchtone telephone augmented by four functions. The user first decides from a printed menu what information is desired (the most popular seems to be weather and market price data). He dials the central computer, obtains a dial tone, punches in the menu items for up to 16 pages (a "page" is one TV screenful), and then hangs up. The information requested is sent to his Green Thumb box which stores it and displays it in sequence on his home television screen. This system is intriguing both as a rudimentary form of Videotex (cf. Vol II) at the PC level and as a form of government subsidy for special groups. In the case of the panel forecast, the concept is to provide PC access to those who cannot otherwise afford it so that the U.S. does not create a class of informatiuon-poor individuals.

The substitution of communications for transportation ("telecommuting") has been discussed in the literature since the early 1960's. Two major studies of possibilities were sponsored by NSF during the 1970's, one at the University of Southern California and the other at SRI International. The University of Southern California study of telecommuting included, among other things, a case study of a major insurance firm that showed that such substitution were economically advantageous to both the company and its employees. There are currently a few scattered working examples of such substitutions. Thus, its introduction by large firms as a regular mode of operation is certainly within the reasonable range of expectations for the 1985-90 period.

Three of the events in the Delphi inquiry were judged to be most likely to occur beyond 1990 or never. In all three cases, there were many panelists who believed that there was no probability at all of these events occurring. The events were:

1. A requirement to register personal computers, just as CB's are registered

2. Enactment of Federal legislation that would make home PC's subject to the Privacy Act of 1974.

3. Imposition of a requirement of the Internal Revenue Service that income tax returns for all businesses with at least $1 million (1978 dollars) annual sales be submitted in machine readable form.

Of these, the registration concept was expected never to occur. A corollary question to event occurrence is event impact. The occurrence of an event may be interesting, but if it has little or no side effect, there may be few or no policy implications. The Delphi panel was therefore asked to assess impacts of events on one another, on the various PC markets, and on general societal issues. In terms of policy planning, it is the combination of timing of events and size that are important.

Table 3-3 shows the estimated effects of each event on the four segments of the PC market if the event occurs.

For convenience of analysis the panelists responses were converted to numeric values from 1 to 7 as shown in Table 3-3. Thus the lower the score the more positive the effect, the higher the score the more negative the effect. The values shown in Table 3-3 are the median responses of the panel.

The following near-term events were judged, using the panel results, to have significant (average between medium and high) positive effects:

TABLE 3-3

EXPECTED EFFECTS OF EVENTS ON PERSONAL COMPUTER MARKETS IF THEY OCCUR

EVENT	Home	Small Business	Large Business	Education
1. SEARS	[1.4]	2.3	3.7	2.5
2. IBM	2.8	[1.9]	[1.7]	2.3
3. TIMEX	2.1	2.8	3.0	2.6
4. JAPAN	2.0	2.2	2.7	3.4
5. CB CRAZE	[1.2]	3.0	3.6	2.6
6. PC NETWORK INFORMATION SYSTEM	[1.6]	[1.8]	2.7	2.2
7. PC VIEWDATA	[1.6]	2.1	2.7	2.2
8. PC POLLING	2.7	3.5	3.5	3.3
9. AT&T	2.3	2.4	2.4	2.7
10. 32-BIT PC	2.3	2.0	2.0	2.3
11. $50 FLAT SCREEN	[1.7]	2.2	2.6	[1.9]
12. DYNABOOK	[1.4]	2.1	2.4	[1.5]
13. REGISTRATION OF PC's	4.3	4.0	4.0	4.2
14. PIRATELESS SOFTWARE	3.1	2.8	3.0	3.0
15. INSTITUTIONAL SOFTWARE PROTECTION	3.0	2.7	3.0	2.9
16. ENCRYPTION FOR PC's	2.9	2.6	2.6	2.8
17. PRIVACY ACT APPLIES TO PC's	3.9	3.5	3.4	3.6
18. SUBSIDY FOR LOW-INCOME PC USE	2.6	3.2	3.4	2.4
19. COURSEWARE DEVELOPMENT	[1.9]	3.4	3.5	[1.2]
20. HOME MONITORING	[1.7]	3.3	3.6	3.5
21. IRS REQUIRES COMPUTER REPORTS	3.5	[1.8]	2.7	3.6
22. 10 FORTUNE 500's USE PCs TO SUBSTITUTE FOR TRAVEL	2.6	2.6	[1.6]	3.3

[ ] = SIGNIFICANT POSITIVE EFFECT

MAGNITUDE OF EFFECT SCALE

1 = High Positive
2 = Medium Positive
3 = Low Positive
4 = No Effect
5 = Low Negative
6 = Medium Negative
7 = High Negative

Home Market:

1. Entry of a national retailer
2. Low-cost computer based network information system
3. Initial marketing of PC courseware for elementary school instruction

Small Business:

1. Mainframe entry in the market
2. Low cost computer based network information system

Large Business:

1. Mainframe manufacturer entry into the market

Education:

1. Initial marketing of PC courseware for elementary schools.

In the intermediate 1985-90 period, the following events would have significant positive effects:

Home Market:

- a CB-like craze for PC entertainment
- a PC equivalent of Viewdata
- Technical developments such as the $50 flat screen and Dynabook
- Inclusion of PC's for monitoring in new house

It was intriguing to the technology assessment team that the panelists, with only one exception (registration of PC's), on balance forecast positive effects from each of the events listed. We therefore examined the detailed data distributions to see whether the results appeared consistent. Our subjective conclusion is that they do. For example, in the case of a CB-like craze for personal computer entertainment the major effect is on the home market (Table 3-4). The values for small business indicate a small sentiment for some spillover into this market. For the business market, the panel strongly sees no effect whereas for the education market, there is a division of opinion with a few feeling that this event would inhibit rather than encourage educational adoption.

In the case of registration of PC's (Table 3-4) as a crime prevention measure, the responses balanced were clustered closely to the no effect point. In the case of each market, there were individuals who felt that registration would enhance the market by making PC's more secure against theft while others felt this policy would deter purchase. The predominant response in all four markets was that of no effect.

Examination of the other events both in summary and in detail on individual questionnaires also indicates consistency of the results. We can find no evidence of panelists mistakingly marking positive effects when they intended negative ones. The conclusion we draw is that our panelists tend to judge effects broadly and perhaps enthusiastically, thereby resulting in very positive average values. However, by discounting these numeric results and only assigning significance to averages of less than two, we believe we have compensated for panel enthusiasm.

TABLE 3-4

Distribution of Responses For Market Impacts of Two Events

Event 5: CB-like Craze for Personal Computers

MARKET

SIZE OF RESPONSE		HOME	Small BUSINESS	Large BUSINESS	EDUCATION
H	1	21	2	1	6
M	2	2	5	1	9
L	3	2	9	6	3
O	4		9	16	6
-L	5				1
-M	6				1
-H	7				
Mean		1.2	3.0	3.6	2.6

Event 13: Registration of PC's

MARKET

SIZE OF RESPONSE		HOME	Small BUSINESS	Large BUSINESS	EDUCATION
H	1	1			
M	2	2	1	1	1
L	3	3	5	6	4
O	4	9	13	14	12
-L	5	5	7	4	6
-M	6	5		1	1
-H	7	1			1
Mean		4.4	4.0	4.0	4.2

The Delphi panel also considered the effects of events occurrences on four market segments:

- the house
- small business
- large business
- education

Panelists were asked to indicate whether effects would be high, medium, low, or none. The following near-term events were judged, using the panel results, to have significant (average between medium and high) positive effects.

Home Market

1. Entry of a national retailer

2. Low-cost computer based network information system

3. Initial marketing of PC courseware for elementary school information

Small Business

1. Mainframe manufacturer entry in the market

2. Low cost computer based network information system

Large Business

1. Mainframe manufacturer entry into the market

Education

1. Initial marketing of PC courseware for elementary schools

In the intermediate 1985-90 period, the following events would have significant positive effects:

Home Market:

- a CB-like craze for PC entertainment

- a PC equivalent of Viewdata

- Technical developments such as the $50 flat screen and Dynabook

- Inclusion of PC's for monitoring in new houses

Education:

- The flat screen and dynabook capabilities

2.2 Trends

Whereas events are one-time or repeating occurrences, trends represent continuous, ongoing processes. Typical familiar examples of trends are population growth, the number of people employed, and gross national product. Although most trends tend to fluctuate, smoothed curves through the data indicate the general direction and magnitude of changes. In the Delphi study, inquiries about a number of trends were included that dealt with the market for personal computer hardware and software, the associated costs, and types and extent of applications of personal computers.

Market Forecasts

Table 3-5 summarizes the forecasts of market trends for both hardware and software. The panelists were asked to estimate the annual sales, in number of units, for the total PC market, small business, large business, and education. For both types of business users, the market estimates were further divided into units costing less than $5,000 (in 1979 dollars) and more than $5,000. The "home and other uses" category reported in Table 3-5 was obtained by subtracting the market segment estimates from the estimates of the total number of units.

Forecasts of annual sales are presented in Table 3-5 in terms of the number of units sold in 1978, 1985, and in 1990. The results show an average annual growth rate of 32.3% between 1978 and 1985 and 26.6% between 1985 and 1990 for the total market. That is slightly faster growth in the early period and slower growth in the latter period. However, the growth rates differ by segment. These differences in growth may be due, in part, to the anticipated decline in computing costs. The capabilities of the Apple II computer were used as a reference standard for cost comparison. The costs of obtaining the capabilities of the basic unit were estimated to be halved by 1985 (from $1200 to $590), and halved again (to $300) by 1990. This decline in cost for equivalent capabilities is reflected in the slower growth in PC sales above $5,000, compared to those below $5,000, for both large and small business users in the 1985-90 period. Furthermore, the data imply that acceptance of PC's will be more rapid in the business community than in other segments.

The growth rate in the educational sector will be quite slow, according to the panelists. Actual 1978 sales to education are known to be small (of the order of several thousand) but are not known exactly. However, after an initial surge in the early 1980's, the educational market is forecast to be essentially flat during the 1985-1990 period. Furthermore, the educational segment appears to be quite small, with sales of only 60,000 units by 1990. These data support the point of view (in Section 4.1) that the educational market will not have significant growth. Note: the estimates for the educational market refer to units bought by school systems, not the use of PC's by individuals or noneducational organizations for educational applications.

The estimates of PC sales by the Delphi panel are compared in Table 3-6 with the high and low estimates made independently by the USC Project Team. The Delphi panel estimates fall between these high and low estimates. Since most of the purchases occur in the later years, the number of repeat purchasers should be small relative to the total and hence should not affect the conclusion.

The software estimates in Table 3-5 are in constant (1979) dollars. Since software costs do not correlate with machine cost, small and large business users are aggregated. Dealing with dollar costs requires some care, even when inflation factors are removed because of the increases in

HARDWARE	1978	1985	1990	Software	1978	1985	1990
Price of Apple II	$1200	$590	$300				
No. of Units sold (Annual)							
Total	225K	1.6M	5.2M				
Small Business <$5000	30K	290K	1M	All Small Business	$2M	$26M	$97.5M
Small Business >$5000	15K	75K	130K				
Large Business <$5000	25K	220K	570K	All Large Business	$1M	$19.4M	$98.3M
Large Business >$5000	15K	100K	200K				
Education	several K	50K	60K		$50K	$5.2M	$20.5M
Home and other uses	140K	850K	3.2M		$1M	$21M	$105M
Software Cost Index					1	0.8	0.4
No. Who can Program in U. S.	5M	10.3M	21.4M		5M	10.3M	21.4M
No. of Retail Outlets in U.S.	8200	18K	41K				

M= millions
K= thousands
All dollar values in 1979 dollars

TABLE 3-5

DETAILED MARKET FORECASTS BY DELPHI PANEL

TABLE 3-6

COMPARISON OF DELPHI PANELISTS MARKET ESTIMATES WITH USC HIGH AND LOW ESTIMATES

		Annual Units Sold (000's)			Cumulative Units Sold (000's)	
		1978	1985	1990	1985	1990
USC HIGH						
	CONSUMER	170	3,050	8,803	7,610	39,083
	EDUCATION	15	250	538	650	2,875
	OFFICE	40	788	3,450	1,865	11,848
	TOTAL	225	4,088	12,800	10,225	55,800
DELPHI PANEL						
		225	1,600	5,200	5,800	23,000
USC LOW						
	CONSUMER	125	882	2,424	3,070	11,092
	EDUCATION	15	74	150	304	886
	OFFICE	85	350	604	1,587	4,041
	TOTAL	225	1,306	3,178	4,961	15,999

productivity to be anticipated for software. Specifically, the panel was asked to estimate the cost of a quality payroll program that cost $500 in 1978 as a surrogate for estimating software costs. The estimates of $400 in 1985 and $200 in 1990 imply that, to a first approximation, a software cost index should be defined. That is, software costs are 0.9 in 1985 and 0.4 in 1990, as compared with 1.0 in 1978. The annual growth rates in dollar value of software sales for the 1985-1990 period, based on Table 3-5, are in the 30 to 40% range and are greater than the growth rate for the number of units. In particular, the education market appears, despite its relatively small sales in number of units to be a significant potential user of software (See Section 4.1).

Although software sales have high growth rates, these growth rates really reflect the growth in the number of units sold. Table 3-7 shows the number of dollars spent per unit sold. The data show relatively small expenditures for software/unit. It is probably reasonable to assume that most software (with the exception of entertainment software) is bought with the unit or shortly after its acquisition and therefore appropriate to attribute software sales to new unit sales.

Although the absolute dollar values of software sales may seem small from the point of view of software vendors, the data make more sense if the productivity increases anticipated are taken into account. Table 3-7 also shows "1978 equivalent costs". The numbers on these columns of the tables were obtained by dividing the actual dollar sales by the productivity increases. Thus, for example, an $86 expenditure by a small business in 1990 buys the equivalent of $215 in 1978 software. A second factor that needs to be taken into account in interpreting the data is that software becomes more significant relative to the cost of the computer.

It is possible, using the data, to speculate that new simplified programming languages for PC's will come into being and into general use, and that these languages will be furnished as part of the initial unit sales. The trend to simplified languages is already in evidence in some of the financial planning languages that are available for large mainframes.

For example, in IFPS (the Interactive Financial Planning System marketed by Execucomm of Austin, Tex.), instructions are written in natural language form. For example, Table 3-8 shows a typical transaction using this software. This simple program generates a 5-year forecast based on current values and assumed growth rates of 10% in market and 7% in selling price. Built in functions compute net present value. The important point is not the specifics of this particular language or program; rather it is the idea that easy to use languages, even simpler than this one, will be developed and possibly given away with the computer as a way of inducing purchases. Incidentally, the experience of one of the team members indicates that people without programming experience and with no computer skills can be trained to write complex models in IFPS with only two hours of training.

The alternative hypothesis that computer programming skills will disseminate at a rate sufficient to sustain the market is not supported by the data. With 5.4 million people in the U.S. estimated to be able to program in some computer language, in 1978, less than 10% had actually bought PC's. The estimate for the number who can program increases to 21.4 million in 1990. With cumulative sales of 23 million forecast by that time, the ratio of machines to programmers becomes greater than one. It appears highly unlikely that such a ratio can be achieved without major changes in educational activities, computer languages, and available "canned" programs for PCs.

The Personal Computer Distribution Network

TABLE 3-7

DOLLARS SPENT OF SOFTWARE/UNIT SOLD

USER	DOLLAR VALUE			1978 COST EQUIVALENT	
	1978	1985	1990	1985	1990
SMALL BUSINESS	44	71	86	89	215
LARGE BUSINESS	25	61	127	76	317
EDUCATION	-	104	340	130	850
HOME	7	25	33	9	82
(INDEX)				(.8)	(.4)

TABLE 3-8

```
List

MODEL MODEL 1  Version of 06-17-80  23:15

1  Columns 1981, 1982, 1983, 1984, 1985
2  TOTAL MARKET = 100000, PREVIOUS TOTAL MARKET*1.10
3  MARKET SHARE= .25
4  MARKET = TOTAL MARKET*MARKET SHARE
5  SALES=MARKET*UNIT SELLING PRICE
6  UNIT SELLING PRICE = 10.50, PREVIOUS UNIT SELLING PRICE*1.07
7  CONTRIBUTION TO PROFIT = 0.20* SALES
8  INVESTMENT=50000,50000.25000,0,0
9  PRESENT VALUE=NPVC (CONTRIBUTION TO PROFIT,.25, INVESTMENT)
END OF MODEL
?  SOLVE
MODEL MODEL1 VERSION OF 06/17/80  23:15 -- 5 columns 8 variables
ENTER SOLVE OPTIONS
? ALL
```

	1981	1982	1983	1984	1985
TOTAL MARKET	100000	110000	121000	133100	146410
MARKET SHARE	.2500	.2500	.2500	.2500	.2500
MARKET	25000	27500	30250	33275	36603
SALES	262500	308963	363649	428015	503773
UNIT SELLING PRICE	10.50	11.24	12.02	12.86	13.76
CONTRIBUTION TO PROFIT	52500	61793	72730	85603	100755
INVESTMENT	50000	50000	25000	0	0
PRESENT VALUE	-8000	-8453	12785	47848	80863

```
ENTER SOLVE OPTIONS
```

The 1979 estimate for the number of retail outlets for PC's was 8200. This number includes the over 7000 Radio Shack stores that market the TRS-80 series as well as 1000 independent computer stores, and 200 others, such as department stores. As a first approximation, it can be assumed that home and small business users would deal primarily with retailers while large business and education users would deal with wholesalers or directly with manufacturers. Even in the present market this dichotomy is not exactly true; however it will serve to indicate the over-all direction in which things are moving. We assume, for purposes of illustration, that the $1200 Apple II is the average unit sold. This point can be argued, but the Apple II serves as a reference for the decline in PC mainframe prices. Based on the number of units sold to consumers and businesses, the number of retail dealers, and the dollar cost per unit, it is possible to compute:

- the average number of units sold per dealer
- the average annual dollar sales of mainframes per dealer.

As can be seen from the results in Table 3-9, although the average number of units goes up from 24 to 102, the decrease in unit price from $1200 to $300 results in a relatively stable income from mainframes for the dealers. The growth in income (and hence in profitability) will have to come from the sale of peripherals (printers, modems, storage, etc.). The growth of the software market has already been discussed; the trends in peripheral costs are discussed later in the chapter.

Related Trends

The Delphi panel provided forecasts for a number of trends that relate to the personal computer business. These trend values are given in Table 3-10. Several of these trends relate to the detailed studies undertaken as part of this assessment, while others deal with costs that will be affected by technological growth.

The panel forecasts a growth to 300,000 of the total number of new jobs to be created by the personal computer industry (implying an industry with $6 billion in annual sales). These jobs include both those within the industry (manufacture, sales, maintenance, software) as well as those in industries created by PC's (consumer-oriented software, maintenance services, information services, accessories). The PC was also forecast to become a major item in international trade. By 1985, 510,000 units are expected to be exported and 190,000 imported. Assuming a conservative $500 average wholesale price per unit, this would imply a net contribution of $160 million to the balance of trade. By 1990 however, while the volume of exports is expected to increase to 1.1 million units the volume of imports increases much more rapidly to 970,000. Thus, while the balance of trade would be favorable, the net difference of 130,000 units at a conservative wholesale price of $250 (based on decreasing cost of Apple II capability) would contribute only $32 million to the nation's balance of trade (see Section 4.3 for a discussion of our independent estimates).

The panel was also asked to forecast the trends in costs for three PC peripherals: secondary storage, displays, and modems. The survey of current users indicates that many PC buyers intend to upgrade their mainframes rather than replace peripherals.

The research team felt that there was likely to be a correlation between the diffusion of personal computer technology and sales of interactive network information services. Table 3-11 indicates the panelists' opinions concerning the growth of interactive network information services. Large

TABLE 3-9

THE PC DISTRIBUTION NETWORK

	1978	1985	1990
No. of Units Sold to Home and Small Business Users	200K	1.14M	4.2M
No. of Retail Dealers	8,200	18,000	41,000
No. of Units/Dealer	24,4	63.3	102.4
Average $/unit	1,200	590	300
Average/Annual Dollar Sales of Mainframes/Dealer	$29,200	$37,300	$30,700

TABLE 3-10

TRENDS IN THE PERSONAL COMPUTER BUSINESS

TREND	1978	1985	1990
Net No. of New Jobs Created by PC's	10K	50K	300K
PC Exports (Units)	20K	510K	1.1M
PC Imports (Units)	0	190K	970K
Cost of 1 Megabyte of Storage (Dollars)	15K	4,400	940
Cost of 512x512 Element Display (Dollars)	10K	2,500	750
Cost of Modem For PC's (Dollars)	150	75	25

ALL DOLLAR VALUES IN CONSTANT 1978 DOLLARS

TABLE 3-11

INTERACTIVE NETWORK INFORMATION SERVICE SALES
(Millions of Dollars)

USER	1978	1985	1990
Small Business	1	6	16
Large Business	10	75	100
Education[1]	5	9	20
Home	-	10	50

Numbers denote annual sales in millions of dollars

[1] Includes Plato and similar systems

businesses are seen as the major purchasers of such services, although the panelists expect to see a fairly rapid increase in home network information service sales toward the end of the decade. Table 3-12 shows the panelists' forecasts of the acceptance of three specific network related services: telecommuting, electronic mail, and home health monitoring (presumably network connected for emergency situations).

It is also interesting to note the trends in the panelists' thinking between Round 1 and Round 2 of the Delphi Study. Table 3-13 shows the changes in forecasts between these two rounds for the nine trends which showed significant changes between Rounds. For some of the trends such as the effects of PC's on new job creation, the panelists became decidedly more conservative. For others, such as the number of PC's used in elementary and secondary education and annual dollar sales of software to large businesses, the panelists became more expansive. All of the events and trend related data reported elsewhere in this are based on the second round results.

3. Cross-Impact Analysis

The forecasts from the Delphi panel represent expected values. That is, they are based on "all other things being equal". However, all other things are rarely equal in real life. An event either occurs or does not occur. If it occurs, it happens at a particular time. When an event occurs, it can affect the probability for other events occurring and it can result in changes in trend values. For example, the Delphi panel indicated that if Sears were to enter the market, this event would increase the probability of both IBM and Japan entering the market (presumably by increasing the size of the market channel substantially). Furthermore, occurrence of this event would make a CB-like craze for personal computers more likely and would also lead to a significant increase in the trend values for annual sales to the home market. Note that by inference, if the event is highly likely (as the Sears market entry was) the non-occurrence of the event should have an inverse effect on these probabilities and trend value.

Cross-impact analysis provides a systematic way of taking these interactions into account. For each event, the Delphi panelists were given a list of potential events and trends that might be affected if the event occurred. For each such interaction, a possible direction of change, increase or decrease, was indicated. The panelists were asked to agree or disagree with the potential impact and with its direction. They were also asked to add other events and trends that would be affected if the event occurred. These relatively open-ended questions were in addition to the questions on the effect on the sales in various market segments (home, small business, large business, educational) described in Table 3-3. The data in Table 3-3 reflect cross-impacts on market trends.

Table 3-14 summarizes the additional cross-impact information that was obtained. In this matrix, each event is shown as both a row and a column. The abbreviations are those which were used in Table 3-3, the event set of the Delphi inquiry. Two events and a trend were identified as interacting with the event set. These were:

Event X1 Development of natural language software

Event X2 Occurrence of a depression

Trend X3 Increasing level of PC crime

The + and - in Table 3-14 should be read in the following way:

TABLE 3-12

APPLICATIONS OF PERSONAL COMPUTERS

	1978	1985	1990
No of Workers Who Use Personal Computers to Reduce or Eliminate the Commute to Work	--	0.5M	1.0M
No. of Homes That Can Be Reached Via Electronic Mail	--	1.5M	6.8M
No. of Homes Using PC's For Health Monitoring	--	50K	300K

M= Millions
K= Thousands

TABLE 3-13

SUMMARY OF CHANGES IN FORECASTS FROM ROUND 1 to ROUND 2

TREND NO.	TREND DEFINITION	YEAR	1st ROUND VALUE	2nd ROUND VALUE
7	No. of PC's Used In Elementary and Secondary Education	1985	100K	200K
9	New Jobs Created by PC's	1985	200K	50K
10	No. of Homes Reached Directly by Electronic Mail	1985 1990	4.5M 10M	1.5M 6.8M
11	Percent of First Class Mail Sent Via PC's	1990	20%	12.5%
12	No. of Homes Using PC's For Health Monitoring	1985 1990	500K 500K	55K 330K
14	No. of PC's EXPORTED by U.S.	1985	750K	510K
20	No. of Retail Outlets For PC's	1990	30K	41K
22	Annual Dollar Sales of Software to Small Business	1990	50M	97.5M
23	Annual Dollar Sales of Software to Large Business	1990	30M	98.3M

K= Thousand
M= Million

Event No.	Event Name	1	2	3	4	18	8	9	12	19	5	17	25	7	13	14	24	15	16	20	21	22	23	X1	X2	X3	
1	SEARS		+		+	+																					3
2	IBM			+																							1
3	TIMEX					+																					1
4	Japan		-			+																					2
18	CB CRAZE		+	+	+																						3
8	PC Network Info System								+			+											+				3
9	PC Viewdata					+			+																		2
12	PC Polling																	+									1
19	AT&T						+																				2
5	32 Bit PC												+														1
17	$50 Flat Screen												+														1
25	Dynabook																										
7	Registration of PC's																									-	1
13	Pirateless Software															-											1
14	Institutional Software Protection														-		-										2
24	Encryption for PC's														+			-								-	3
15	Privacy Act applies to PC's						-										+										2
16	Subsidy for low-income PC use																						+				1
20	Courseware Development																										
21	Home Monitoring																									-	1
22	IRS Requires Computer Reports																									+	1
23	PC's Used to substitute for trip to work																		+								1
X1	Natural Language Software	+				+																					2
X2	Depression	-	-																								2
X3	High PC Crime Level													+			+										2
		3	3	2	2	5	2	1	2	0	0	1	2	1	2	1	3	2	1	0	0	0	2	0	0	4	39

TABLE 3-14

CROSS IMPACT MATRIX FOR EVENTS

For +: If the event whose name appears in the row occurs, the occurrence of the event in the column becomes more likely (if it has not already occurred).

For -: If the event whose name appears in the row occurs, the occurrence of the event in the column becomes less likely if the event in the column has not yet occurred.

It can be seen that the matrix is relatively sparse with only 39 of the 625 possible interactions taking place. This 6.24% density (10 to 20% densities are more typical) reflects the fact that the range of the inquiry was large. There are, however, clusters of interaction, with the market items and the software/hardware protection items having fairly strong interactions.

With only 2 rounds of the Delphi process, it was not possible to obtain quantative estimates of the magnitudes of the interactions among events and run a formal cross-impact analysis. However, the matrix shown in Table 3-14 does provide a framework for thinking about the interactions among events.

CHAPTER 4:
PERSONAL COMPUTERS AND EDUCATION

If we include all forms of formal education, from kindergarten through formal "schooling" in high schools and universities, vocational training, industrial and adult education, and military training, the educational enterprise is the largest industrial enterprise in the United States. Annual expenditures for the combined total of these forms of education are difficult to determine. However, even if we confine our attention to primary and secondary schools and colleges - the educational "establishment" - we account for 7.1% (in 1978) of the Gross National Product, or just over 1/3 more than the amount the United States spends on national defense. Budgeted Federal outlays for education and training in FY 1981 are $25.7 billion. The educational establishment, then, is one for which public policy has a major economic impact in both the near and long terms. Since personal computers, as the embodiment of a highly developed information technology, hold considerable promise for improving education and consequentially many other aspects of contemporary American society, this area has been a focus of our interest.

Although computers are not new to education, personal computers are. The question is whether personal computers bring any unique set of attributes to the education scene which might both help alleviate some of the symptoms just listed and provide new opportunities for education. If so, what policy options are available to the Federal government and other agencies which would work to take advantage of the opportunities?

Personal computers have already generated considerable enthusiasm among innovative teachers and anxious parents. They are viewed as major new tools for shoring up or resurrecting an educational system widely believed to be in general disrepair, particularly in the larger cities of the United States. Symptoms of the need for change are the declining level of adult functional competency (with 20% of the adult population listed as marginally competent), declining levels of performance in scholastic aptitude tests and increasing numbers of failures in statewide competence tests (such as the New York Regents examination), a decreasing percentage of students continuing their education past high school, and declining levels of learning in the sciences. (Social Indicators, 1976; Aiken and Braun, 1980). All of these indicate decreasing productivity on the part of educators, learners, or both.

1. Educational Uses of Personal Computers

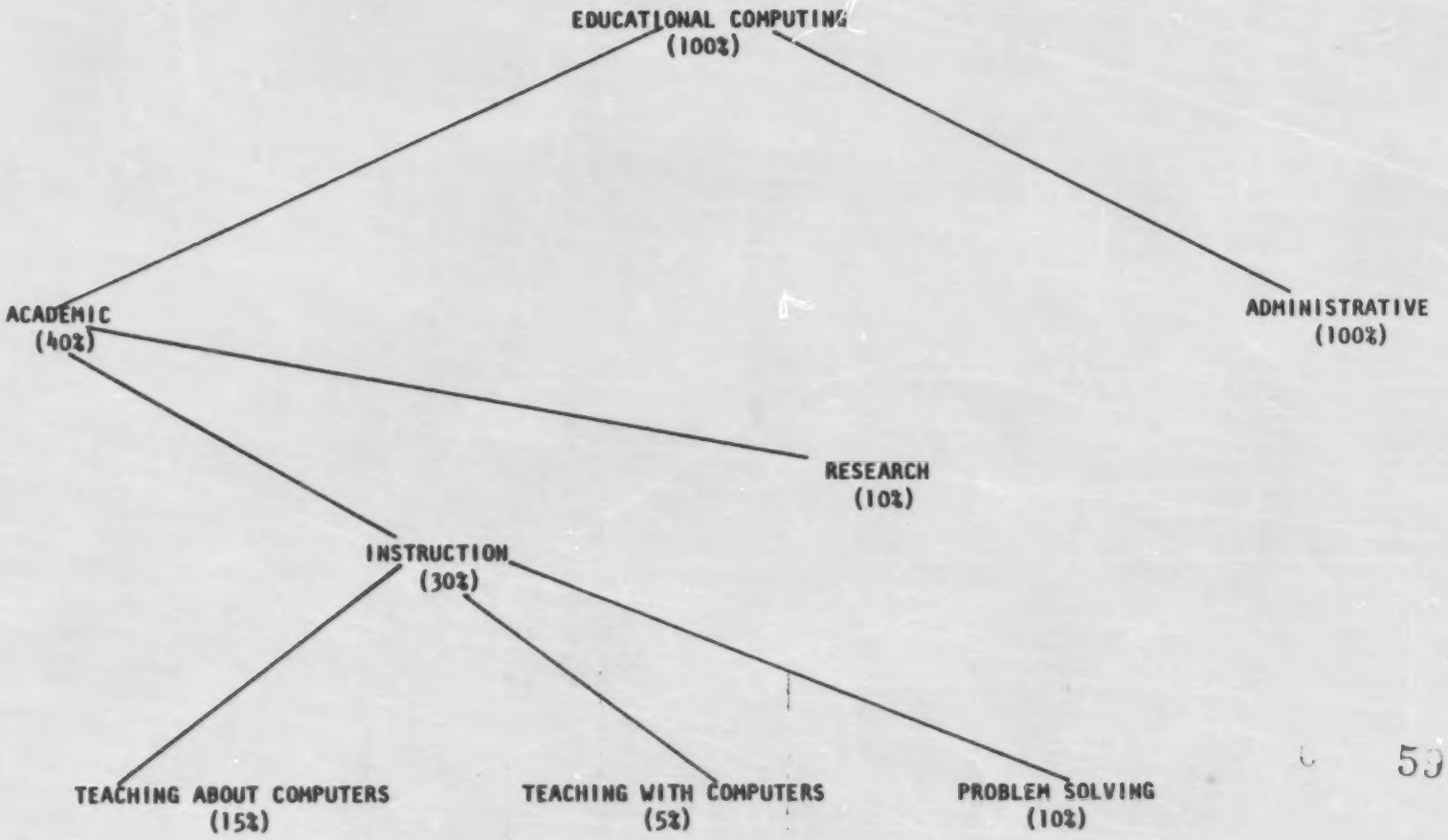
As Figure 4-1 shows, the educational applications of computers can be categorized into two broad areas: administrative and academic computing. (Kniefel and Just, 1979). Academic uses of computing, about 40% of the total, can be further broken down into instruction and research applications. A brief description of each of these follows.

1.1 Administration

Sixty cents of the educational computing dollar is spent on administrative applications. Most of the administrative uses of computers in education are identical in concept to computer applications in business: accounting, payroll, inventory control, text processing, and management information generation. The fact that the commodities which are the subject of the actions of the computer systems are students and their records of progress does not materially alter the nature of the information processing activities.

As is the case with business and government organizations, the uses of

FIGURE 4-1



/Source: Association For Educational Data Systems

computers have been confined primarily to the larger institutions in the past, because of budget limitations in the smaller school systems. Personal computers now provide the same sorts of opportunities to the smaller schools and school districts, a direct parallel to the diffusion of personal computer technology into small businesses.

In addition to being the first introduction of computers in many schools, personal computers may also replace existing older computer installations since in many cases personal computers can provide an increased level of service at a lower cost than the older computers. Further, some schools may partially or totally dismantle older, mainframe timesharing systems in favor of more reliable, independent personal computers, since various forms of small multiuser sytems are already appearing. We expect that at least 60% of the near term applications of personal computers in education will be administrative in nature.

1.2 Academic Applications

The remaining forty cents of the education computing dollar is spent on academic applications. Research takes about one-fourth of this, with the remaining thirty cents left for the topic most people associate with computers in education: instruction. Although definitions vary, the instructional applications of computers can be grouped as follows:

1. Teaching about computers (computer literacy and computer science)

2. Teaching with computers; this includes drill-and-practice, programmed instruction and testing, gaming and simulation, all often lumped together under the title Computer-Aided-Learning (CAL)

3. Problem solving; the use of computers as aids to solving problems in mathematics, the sciences, economics, etc., where the computer is a tool in the process as it often is in research.

4. Information processing; this includes such applications as text or word processing and data base searching. At present, this set of applications is confined largely to secondary (somewhat) and higher (mostly) education or is subsumed under administrative applications, hence is not shown in Figure 4-1.

Personal computers can be used for all of these applications, although presently they are clearly of limited use for some, such as the storage of large data bases. Even in the latter case personal computers will become competent as videodisc and other low cost mass storage technologies become commonly available. Table 4-1 summarizes the uses of microcomputers in education.

Personal computers have an additional important capability not shared by mini- and mainframe computers: portability. This is important in two areas: teaching the mobility handicapped and home (or office) study. Neither of these applications is explicitly included in our projections of the market for personal computers in education, primarily because of the difficulty in finding supporting data. Home uses of educational software are implicitly included in the consumer computer market projections of Volume I. Uses by the mobility handicapped are still largely unexplored in detail, although the general nature of the applications is included in the four categories just described.

CHARACTERISTIC \ STRATEGY	DRILL	TUTORIAL	PROBLEM SOLVING	PROGRAMMING	SIMULATION	TESTING	CMI	DATA ANALYSIS	INFO RETRIEVAL	WORD PROCESSING	COMPUTER LITERACY
Interaction	X	X			X	X	X	X	X	X	X
Lower Case		X			X	X				X	
Graphics		X	X		X	X		X			
Large Data Source		X			X	X	X		X	X	
Specific Language			X	X							X
Multiple Languages				X							
Student Record Keeping	X	X				X	X				
High Student Terminal Time		X		X	X					X	
Large Amount of Text		X		X	X			X	X	X	
Hard Copy Printed Output			X	X	X	X	X	X	X	X	X
Packaged Statistical Programs			X					X	X		

TABLE 4-1

INSTRUCTIONAL REQUIREMENTS MATRIX

Policy Analyses
Education

The likely effectiveness of personal computers, compared with alternatives, in these four types of learning is not completely known but can reasonably be extrapolated from prior experience with larger computers and preliminary experience with personal computers since, at present, personal computer technology is an increasingly large subset of larger computer technology.

Two vital characteristic of personal computers, and of larger computers used in a time sharing mode, are interactivity and self-pacing. Interactivity, perhaps the critical characteristic which distinguishes computers from most other artificial learning aids. The computer interacting with a student can adjust its responses to match the learning ability of the student, whether that ability is great or small. Similarly, the computer can adjust the pace at which it interacts with the student to suit the student's learning rate. Consequently, the computer, with properly written courseware, is widely adaptable to a broad range of student capabilities without modification.

As one of our Delphi panelists put it "Current classroom teaching makes no allowance for individual differences: fast students must learn slower, slow students must learn faster. Thus we treat everyone as a non-existent average. A computer, on the other hand, has infinite patience, allows students to proceed at their own pace and allows everyone to be taught by the best teacher available (if we can convince the best teacher to write the courseware). Teachers will recognize that computers will help them do their job better and more productively, all be it recognition [of this fact] is slower than we would like."

The ability of the computer, via well written courseware, to bring the best available teachers to the individual student is emphatically stated by the same panelist: "The current educational system is a dismal failure; students aren't learning and motivation to learn is not enhanced but rather dampened. Further, a large percentage of students are in rural schools where teachers are not fully qualified and where the right teaching talents do not exist. As a result the rural school doesn't even qualify students for college, let alone a job. If we can't cope with the information explosion, and we have proven we can't in the present educational system, then our society will fail. Computers can help by making all of the latest information available so that fast students will always be challenged with the latest additions to the world's information base." (Delphi Panelist, 1980).

Finally, the computer can be used for forms of learning radically different from those of the traditional classroom. Through the use of simulation techniques, graphics, robotics and other developing technologies, the educational computer can transform dry theoretical topics into realistic enticing learning experiences. As one example, personal computers completed with videodiscs have the potential for extensive and varied interactivity, complete with high resolution, animated graphic displays. (Heuston, 1972). The modes in which personal computers can be used are as follows:

1.2.1 Computer literacy

As our society continues to increase in its information intensiveness it will become correspondingly more important that its citizens be able to interact with computers on a regular basis. The dilemma for any developing technology is whether to invest more in making the machines more easily useable by an uneducated user (e.g., the PHD - for Push Here, Dummy - computer) or to spend greater effort in teaching the user to operate a more complex machine. At its present state of development, computer technology

still requires a fairly subtantial investment in the education of the users if they are to interact with computers at more than a superficial level. Since it is likely that an increasing proportion of the U.S. labor force will be required to interact with computers at a moderately detailed level (see Chapter 5) it is important that familiarity with the operation of computers be taught either by prospective employers or by primary and secondary schools and by colleges and universities. Personal computers are argued to be ideal means for teaching about computers because they:

- do not tie up overloaded, large, timesharing mainframes which as high cost resources, might better be used for more difficult computational activities,

- do not require access to a larger computer, allowing computer literacy to be taught where large systems are not available,

- are available with most of the common higher level languages, making them reasonable analogs of larger systems

- can increase accessibility, particularly in budget constrained school systems, because of their relatively low entry cost.

Thus, personal computers, in principle, will be economically able to provide large numbers of students with a good working familiarity with computer operations. They will have an advantage over the inherently more capable larger computers of the same vintage to the extent that they ease the problems of multiuser access using telecommunications. Even though microcomputers will be used in multiuser modes, these uses will tend to be confined to single-classroom situations, where the interconnections are short cables, not telephone lines.

1.2.2 Computer Aided Learning

The greatest promise of the computer in the educational process is through its role as a tool of the instructional process rather than as an objective of instruction. Almost since electronic computers were built, serious attention has been given to their possibilities for assisting learning. In the last 15 years close to $200 million has been spent by Federal Agencies for research and computer aided learning. since the costs of learning have always been an important factor in the rate of dissemination of computer technology in education, the appearance of a relatively low cost computing capability, as embodied in the personal computer, represents to many educators an exciting new opportunity.

Although the exact definitions vary, the following are the primary modes to which computers are currently used in the instructional process:

Drill and Practice

This is the most common use of computers as aids to learning. It is generally accepted that computers are more efficient than human teachers in conducting routine drill and practice operations, particularly because of their ability to adjust the pace of interaction to the student's needs. Suitable subjects for computer mediated drill and practice are those requiring the rote absorption of information, dates, mathematical operations, routine information processes, etc., where the computer is not required to make value judgments on "fuzzy" concepts. This particular use of computers has

applications far beyond the traditional formal educational system, including adult education and more importantly, in business, industrial, and government training for these later applications, personal computers may be seen as important training tools.

Computer-Managed Instruction

In this use the computer is not necessarily directly involved in the learning process as an element of instruction. Rather the computer is used to perform the administrative chores, such as scheduling, record keeping, and lesson selection, which might otherwise take large fractions of the human teacher's time. One way in which computers might be directly involved in instruction is through their use in automated testing of all students.

Computer Aided Instruction (CAI)

CAI is the focus of much of the research in the use of computers for education. In CAI the computer is used to emulate the behavior of a teacher in a one to one relationship with the student, guiding him or her through the intricacies of the subject to be mastered. An excellent CAI program will augment the student's ability in the areas where he or she is weakest and proceed at a pace appropriate for the student's real rate of learning. Unfortunately, since the reactions of a generalized student are not known *a priori*, the CAI program must have within it the ability to respond to all possible student reactions and proceed accordingly. Consequently a substantial computing capability is required for all but the most rigorously defined subjects. In practice, the effectiveness of fully automated CAI compared with a human teacher is ill-established. Part of the problem is that the learning process itself is not yet well understood; consequently, the development of a high quality CAI program is presently much more of an art than a science.

Gaming and Simulation

Computers are frequently used to simulate physical phenomena, real or hypothetical, or other dynamic processes of a simple or complex nature. These simulations can be explicit as might be the case in traditional appearing instruction in the sciences, or implicit as they might occur in various sorts of simulation games. In either case, the objective is to provide a sense of realism and process to the student. Computer simulations are particularly valuable when it would be expensive or even dangerous to teach in more direct ways. For example, a classic use of simulation in World War II was in the training of pilots with the Link Trainer. Since that time simulation techniques have been used in a variety of instructional settings, as in the case with the use of computers for drill and practice, a very good case can be made for the use of computer simulations as a cost effective means of instruction. A fairly high proportion of existing personal computer game programs use simulation techniques "the computer can be used to generate rich, creative, manipulable environments for the learner, environments difficult to manipulate and experiment with in the real world, even environments which are impossible. This type of computer use is a simulation; we use the computer to model some portion of the real or imaginary world. We prefer the term controlable worlds because it stresses the effect rather than the mechanism." (Bork, 1979).

1.2.3 Problem Solving

In this mode, the role of the computer is that of an aid to the student. The computer performs the tedious calculations and/or logical operations, presents data in meaningful ways, etc., as part of the larger process of finding and underastanding the problem presented to the student. For example, the uses of computers and computer aided design operations is in a problem solving mode; the student (or scientist or engineer, etc.) developed a new design through the use of the computational and graphics display tools embodied in the computer. This mode of application of computers extends far beyond the educational environment and it is widely and increasingly used in business and industry.

1.2.4 Information Processing

Like problem solving, the information processing applications of computers are adjuncts to the instructional process. Although they are of increasing importance, information processing applications may also be the object of the instructional process, as a part of computer literacy courses. For example, students may be taught to operate text processing systems so that they may later find employment performing text processing as an integral part of their other learning functions, such as preparation of papers and reports. Of increasing importance is the ability to interact with one or more computerizd data bases. As in text processing, this ability may be treated as an end product of the instructional process or as a means for furthering other educational goals.

2 Potential Impacts of the Technology

Personal computers can have enormous and widespread impact on all forms of education or they can have none, depending on the specific course which both technological development and public policy decisions take in the coming years. Because of the rapidity of change in contemporary society, continual education of one form or another is becoming a necessity. At the same time, the individual's available time for education is under continual pressure by other time demands. Consequently it would appear to be a logical conclusion that any technology which acts to increase the speed and effectiveness of learning would be welcome indeed.

Personal computers, particularly as they become associated with telecommunications systems and mass storage media such as video disks, promise to provide that necessary educational resource. Personal Computers, because they can be available to their owners at any time of the day or night and, ultimately, at any place, appear to provide an educational medium comparable to the printed book although they are presently considerably less portable. As, and if, the technology improves, compact, portable personal computers with transportable mass storage will replace books for many forms of education and entertainment where the basic cost of the medium (paper vs. magnetic or optical media) as not the prime concern. (See the description of the Personal Information Utility in Volume 2).

The above discussion concerns the topic of education in the abstract. Given sufficient time, funding, and imagination, the descendants of contemporary personal computers will indeed be valuable education tools. However, enthusiasm for what might be must be tempered with some consideration of what is likely to be in the coming few years. The following, in addition to the impacts already discussed in Chapter 3, summarize our findings on the potential near and intermediate term impacts of personal computer technology

in education.

2.1 Economic

The potential economic impacts of personal computer technology vis-a-vis education fall into four categories:

a. The effects on the education market per se. This includes the U.S. public and private, primary, secondary and postsecondary education institutions.
b. Effects on the home or consumer market.
c. Effects on the large organization market. This includes not only large firms in the private sector, but the Federal government as well.
d. Effects on the small business market.

2.1.1 The Education Market

At present, there are approximately 58.5 million people enrolled in the U.S. educational system from K-college. Other statistics that become noteworthy when evaluating the effects of personal computers on the education market include:

1. About 65% of the school districts in the U.S. contain fewer than 1,000 students. Because of the cost factors involved in participating in a large time-sharing network, personal computers would be highly adaptable to this subset of schools.
2. Pupils with handicaps (speech impairments, learning disabilities, emotional disturbances, physical disabilities, etc.) comprise about 10% of the total secondary and elementary enrollment. Much of the current effort in the development of commercially produced CAI is directed at this segment of the school population, especially in the area of basic skills development for the slow learner.

We estimate that at present there are 4,000-8,500 personal computers in U.S. elementary and secondary schools; that is, approximately 5-10%. Examination of this figure in more detail, however, reveals that less than 1% of all elementary schools have personal computers whereas 25-35% of all secondary schools have at least one.

Our market growth model for technological forecasting (explained in Volume II a summarized in Chapter 3 of this report) was asked to generate growth curves for lower bound and upper bound estimates of the number of personal computers in the education market. Our low growth forecast is that 75,000 units will be sold to educational institutions in 1985 and 150,000 units in 1990. The high growth forecast is that 250,000 units will be sold to educational institutions in 1985 and 540,000 in 1990. Factors that affect the growth rate include:

1. budget considerations at the local, state and Federal levels;
2. depth of knowledge at the local level about personal computers and their educational (i.e, instructional and administrative) applications;
3. teacher and administration support for the introduction of personal computers into the curriculum;
4. development and successful marketing of PC-based educational material and equipment by the personal computer industry (e.g, Bell and Howell/Apple).

2.1.2 The Home and Consumer Market

At present, the home market is largely an untapped reservoir for producers of PC-based educational hardware and courseware. The consumer is induced into purchasing personal computers with the lure of space-age games, checkbook balancing, income tax preparation, and a host of other packages. Little is offered at present in the way of educational materials; i.e, courses.

Census Bureau projections state that by 1990 there will be between 90 and 95 million households; curently, there are about 80 million. Our forecasts for the consumer computer market indicate that, ultimately 80% or more of the households in the U.S. will have some form of personal computer.

Based on market growth forecasting model mentioned earlier, growth curves were generated for a low and a high growth rate of sales of personal computers to the consumer population. Our low growth forecast calls for, that about 900,000 units will be sold in 1985 and 2,500,000 in 1990. Our high growth forecast calls for 3,000,000 units to be sold in 1985 and 8,000,000 in 1990. In other words, we predict that between 12% and 42% of all U.S. households will have personal computers by 1990. Thus the home market is and will be a large, viable market for PC-based educational hardware and software when quality courseware is available at a consumer-affordable cost.

2.1.3 The Large Organization Market

Personal computer technology vis-a-vis education affects the large organization market in two main areas. First, the uses of personal computers for production and office work may be extended to include on-the-job training. There is no estimate available for the number of personal computers used currently in industry, but the number of business and industrial applications of personal computers may be made is growing rapidly. Second, purchases of large numbers of personal computers by large organizations, for example, the Department of Defense, specifically for training purposes. Again, figures are not currently available for numbers of personal computers in use in the training process in large organizations. However, it is to be expected that, as training costs rise, personal computer prices fall, and the utility of personal computers for routine training becomes more widely established, they will be broadly used..

2.1.4 The Small Business Market

Under the rubric of "business computers," personal computers have already had an impact on the small business market. It is currently the largest purchaser of microcomputers (See Figure 3). However, the applications to which microcomputers are put to use are mainly business, not educational or training applications. The small business person uses personal or microcomputers for such purposes as inventory control, payroll, general recordkeeping, etc. Due to the cost of courseware development and to the diversity of the small business market in terms of product or service, company size, annual sales, overhead, etc., with the consequent variety of training requirements, we do not forecast a large investment of time and money for the development of personal computer-based educational or training courseware by or for small businesses, with the exception of text processing applications.

2.2. Societal Impacts

Personal computers can have a number of societal impacts as a consequence of their pervasive use in education as with the effects of computers on the workforce the specific societal effects of computers are ill documented and equally well understood. The following are some of the consequences we have considered under the supposition that personal computers are widely used in the United States in all the market areas discussed previously.

Literacy

As mentioned earlier, personal computers appear to be an ideal means for developing computer literacy at relatively low cost. What is less obvious, and possibly counter intuitive, is that personal computers may increase the general literacy of its users over and above what might occur were they not to enter the scene. The mechanism appears to be one of positive reinforcement. As the learner gains proficiency using the computer, adapting to the syntactical discipline and precision in language required by the relatively limited facilities for understanding on the part of the computer, he or she gains confidence in his or her ability to branch out into forms of written expression which are not necessarily computer centered. We already have anecdotal evidence of this phenomenon occurring in experiments made in primary schools in the Santa Clara Valley (for example, as shown in the PBS TV presentation, "Don't Bother Me I'm Learning")

Cultural Assimilation

Like television, personal computers appear to have as great potential for leveling as they do for elevating the masses. The hardware technology is relatively neutral in this respect except that it provides a framework in which new forms of software can be presented the individual. One effect of television which is frequently remarked upon, is its ability to erode cultural barriers to the extent that this will promote greater understanding among different cultural groups it can be seen as a positive effect. Personal computer based education could provide individuals, through its interactive capability, with the experience of sharing in the activities of other cultural groups and, consequently developing a greater understanding of their mores and attitudes. On the other hand, depending on the quality of the software provided, personal computer education can also act to blur many of the interesting differences between various cultural groups. It is not possible at this stage of development of the technology to estimate which of these is the more likely, and in which circumstances.

Educational Standards

In addition to the problem of the growing need for computer literacy, it is becoming increasingly apparent that the educational achievement of students in primary and secondary schools in the United States is generally diminishing. Furthermore, the greatest concern is expressed over the increasing functional incompetence of many American adults to the extent that personal computers can replace scarce teachers in fundamental educational subjects, an area in which computers appear to be most proficient, this trend could be reversed. Furthermore, because of the economic necessity for relatively large marketers to defray the cost of production of quality personal computer software, the likelihood increases that the national

distribution - hence national minimum standards - will develop. National competency tests, similar to those used by the New York Board of Regents, could be developed for use with personal computers. Our Delphi Panelists estimated that computer literacy questions were most likely to appear on Scholastic Aptitude Tests (SATS) in the mid '80s.

Anomie

The objectives of education might be grouped into two categories: learning to cope with the physical environment, and learning to cope with other humans. Personal computers can be quite efficient at the former but there is no evidence that they are particularly adept at the latter; in fact, there is some concern that personal computers, and computers in general for that matter, can act to dehumanize individuals, isolating them socially and increasing their difficulty in coping with other individuals. Each university computer center seems to have its set of "hackers", or "students (or faculty) who become totally immersed in interacting with the computer to the gradual exclusion of almost all human contact." Since, in the past, computers have largely been confined to postsecondary educational institutions, government and industry, this phenomenon has been relatively restricted in its impact. The question is, if personal computers become prevalent in primary and postsecondary, adult, and special education as well, will the population of desocialized or unsocialized individuals increase as a consequence? On the other hand, will personal computers, to the extent that they increase individul feelings of self-worth because of successful participation in the instructional process, increase the ability of some people to participate successfully in social interaction where they might otherwise not ha e done so? At present there is no substantive evidence to support either trend.

Equity

Personal computers are still expensive compared with more traditional learning materials such as blackboards and books. As a consequence, personal computers are more likely to be adopted by schools and individuals in affluent rather than low-income areas unless public policy somehow compensates for differences in purchasing power. However, since institutional learning is only part of the educational process, it is still likely that the economically advantaged, through private ownership, will be able to use personal computers as educational tools earlier than those who are less economically advantaged. If personal computers fulfill their potential to make learning more effective and to increase learning speed, then the learners in these economically advantaged strata will increase the educational gap between themselves and those who do not have access to personal computers. The net result will be a widening of the gap between socio-economic classes. Higher income learners will become more competent than low-income learners and, to the extent that this increases their productivity, their income differences will increase; a clear example of a failure of the market process to provide equal opportunity of access to education.

Crime

Widespread acceptance of personal computers will presumably lead to an increase in computere associated crime. The most likely occurrences of such crimes will be in those cases where the criminal is computer proficient and the victim is not, or has not developed adequate safeguards against computer crime. This forecast is made on the assumption that criminals occupy roughly the same spectrum of mental and learning capability as do ordinary citizens, then, as computers become available to many people via personal computer technology some fraction of these new learners, those who already have

criminal tendencies, will use personal computers as the tools of or victims in their crimes. As criminals become computer literate, computer-related crime will increase. Although the topic of computer crime was not covered in detail in our assessment we did make some preliminary estimates to the effect that crime involving personal computers could have a value as high as $2 billion annually in the 1990's. In some sense this crime rate would be due to a combination of expertise on the part of the criminals, ignorance on the part of the victims (a function of their level of computer illiteracy), and lack of adequate safeguards against such crime.

2.3. Institutional Impacts

The type and extent of any structural change in the educational process which might result from the uses of personal computer technology correspond to the level of use of the technology within the educational system. Our estimates are based on current trends; however, it is useful to delineate the two extreme positions of structural change since either one is possible. An intermediate position is more likely.

Low Impact Position

— Personal computers will have little effect on the educational system, either in numbers or in application. There is no reason to believe that personal computers will have any greater or less effect than any other audio-visual device. The arguments presented there point out that any structural change in the educational system as we know it will not be influenced by personal computer technology.

High Impact Position

— Personal computers will cause profound structural changes in the educational process. It is conceivable that as high quality and large quantity personal computer-based courseware becomes available, and that as acceptability and eventual accreditation of this medium of study becomes widespread, structural changes may occur that would affect the entire structure of society. For example, the home becomes an educational institution. Due to the rising cost of transportation, staff and building maintenance and due to the decline in enrollment in public, primary, and secondary schools, budget allocations go to parents rather than school systems and studying at home via personal computers become more desirable.

2.4. Legal Impacts

Legal impacts with regard to personal computers in education will fall into the category of school (district) compliance with government regulations. Presently no regulations explicitly involving personal computers exist; however, indirect legal questions related to personal computers may be considered. For example, if it is shown that computers applied to educational endeavors can significantly extend a person's intellectual abilities and if a substantially greater portion of affluent schools (vs. less affluent schools) use them, then it may be the case that a legal issue concerning the equality of educational opportunity might arise. Court action is then necessary. A

corollary issue that could also arise is a racial one: accessibility to computers by the affluent schools, which are generally white, may be seen as a cover for the continuance of segregationist attitudes and policies.

Another category of legal impacts vis-a-vis personal computers in education, which at this time lies beyond the possibility of predictability, consists of those cases brought against a school or school district due to personal injury caused by a personal computer. It may be the case that as responsibility is given to a computer for supervision of some sort, injury suits may ensue.

3 The Education Market; Opportunities and Barriers

The previous sections covered the general range of possibilities of personal computers in education in terms of the potential size of the education related market in various sectors of the economy and of the potential impacts of the technology for various levels of its adoption. Our Delphi Panelists estimated that about half of the market for personal computers and about 60% of the market for educational courseware was likely to be controlled or heavily influenced by government policy, the remainder having to do with industrial and commercial implant and secondary school systems, split about equally between the two. The panelists estimated that the Department of Defense would spend about the same amount for personal computers in training its personnel as would either the primary or secondary education systems. However, aside from these basic estimates, it is necessary to examine some of the incentives and barriers to the use of personal computers in each of these major market areas. In order to estimate whether free market processes will dominate or whether, conversely, government intervention in the marketplace might be necessary. We have concluded that the arena in which changes in government policy are most likely to be required because of existing impediments to change is that of primary and secondary education. Consequently we have concentrated on this area during the remainder of the project. The other areas will be touched upon as well.

3.1 Primary and Secondary Education

Our research has led us to two apparently paradoxical conclusions:

- **The impact of personal computers on the educatinal process is likely to have no effect on the educational establishment ("Conservative Scenmario", Round 2 Delphi Survey)**

+ The impact of personal computers on education is likely to be more profound than any technology since the blackboard. (Computers and the Learning Society, 1978).

Both of them are likely to be true, although not necessarily in the same places. The first statement forecasts the result if no alterations are made in existing barriers to the use of personal computers (and other forms of educational technology) in primary, secondary and post-secondary education. The second statement refers to some of the possibilities of the technology, as outlined previously, if suitable incentives are provided, and barriers are removed, for the widespread use of personal computers and quality educational courseware.

Perhaps the best way to provide some perspective on existing barriers to educational technologies is through another quotation:

"[Personal computers] are making their educational debut within the

> course of classroom instruction in present day schools and colleges. Coupled with a large scale basic research program in education [personal computers] offer new dimensions for future design in instructional programs. More emphasis can be put on independent learning by students in the classroom and the 50 minute period may become a thing of the past. Textbooks of the future and other printed material may be radically altered to become convenient learning tools to the [personal computer] program. Teachers may enter on a new era of freedom from educational drudgery, leaning heavily on modern technology to give them more time for working with the learning problems of students in their own scholarly pursuits."

The above is an excerpt of testimony given to the Senate Committee on Interstate and Foreign Commerce in January, 1959. The original testimony to the committee had the word "television" in every place where we have inserted the words "personal computer". Instructional television did seem, in 1960, to have substantial advantages over conventional classroom teaching. One of the greatest of these potential advantages was that course material could be prepared and produced by teams of experts in the subject to be presented, presumably resulting in a much better and more efficient presentation than would be possible by the general practitioner teacher in a primary or secondary school. Yet the realities of the use of instructional television in the educational process seem to be a pale imitation of the prospects discussed more than 20 years ago.

As was mentioned earlier, personal computers have some advantages over television in classroom presentation. Foremost among these is that personal computer technology is interactive rather than broadcast in nature. The student becomes involved with the actions of the personal computer rather than being a passive, and not necessarily attentive, recipient of the computer's message. Since personal computers can be linked with television media by using such peripherals as video cassette recorders or videodisk players as peripheral devices, personal computers can have at least all the advantages of television. Nevertheless, one cannot simply discount the past 20 years of experience with instructional television. We conclude that, absent substantial and far reaching policy changes, **in the year 2000, after personal computers have been around the educational system for 20 years, the average classroom will be almost indistinguishible from that of today. This may be the case independent of any inherent virtues or liabilities of personal computer technology.**

A critical barrier to the use of personal computers in education may be technological; specifically, the development of quality courseware. Courseware can be quite expensive. In some sense a vicious circle may operate, manufacturers of personal computer will hesitate to produce new models oriented specifically toward educational applications because they fear that insufficient quantities of quality courseware would be available to stimulate the market for their hardware. Prospective producers of courseware may decline to devote the time and effort required to make it of high quality because of inadequacies in available hardware, and so on. The investment in time and money on the part of the courseware developer is not trivial. In the order of 100 hours of professional time is required to develop each hour of online instruction for an educational computer. In 1980, costs per professional hour are in the order of $35. As competition for professional programmers increases over the next decade, due to 1) a declining number of people in their late teens and early 20's entering the job market and to 2) generally increasing demand for programming skills, the cost per professional hour can be expected to increase at a rate higher than inflation, possibly as

much as 10% per annum. Although some automated aids to courseware development exists, their primary utility is in handling the details of conversion of the instructional materials to specific computer programs. They have very little effect on decreasing the number of hours required to invent, edit, collate, and polish the basic materials. This latter task consumes the majority of the time required to develop the courseware. Hence the courseware development is likely to remain labor intensive and, to make the dilemma more acute, the supply of labor is not likely to meet the demand unless the educational system produces more and better qualified teachers and courseware programmers. When the courseware includes TV materials on videodisks or other media these hourly costs can be multiplied by a factor of two or three because of the elaborate production costs required for pictorial materials.

Technological Considerations

According to a report prepared for the National Science Foundation; "Technology in Science Education: the next 10 years - Perspectives and Recommendations", it is desirable that a typical student should interact with a computer at least 15 minutes per day (Lipsom, 1980). Heines argues that the cost of developing, producing, marketing and distributing the 45 hours of instructional materials required to meet that goal would come to $600,000, including a reasonable return on investment over the lifetime of the product) (Heines 1980).

If we multiply the above number by 13, to cover the provision of 15 minutes of computer based instruction per day for the student from kindergarten through 12th grade then we estimate the cost of a complete K-12 computer based curriculum at just under $8 million. Since the minimum anticipated figure for the population over the next decade in this age group is about 45 million, this comes to cost slightly less than $6.00 per student, or about $.50 per year, to pay for the cost of the software production. Unfortunately, matters are not that simple. First the software producer has a vanishingly small chance that the software will be distributed in that way. Much more likely, particularly given the essentially total lack of legal protection for software, the producer will have to be content with selling in the order of one or two thousand copies of the software, anticipating that each of these copies will be relatively indiscriminately copied further with no return to the producer. Since the producer's price will be based on that estimate rather than the ultimate potential the price per copy of the software would be between $300 and $600 depending on the lifetime of the courseware, media costs for additional copies, the actual number of students who use the courseware, etc., this could result in an actual cost per student of as much as $3.00 per year, instead of a one time cost of $.50 for an entire K-11 curriculum. Thus the realities of the present educational market can make the cost of software almost 100 times what it might be in an ideal situation.

Hardware costs for personal computers in primary and secondary schools might be expected to stay at about $1500, in constant dollars, over the next decade. The reason for this is that, although basic costs of microelectronics, peripheral hardware, and media will continue to decrease in real terms, a difference between the decreasing cost of the basic components and the $1500 system cost is likely to be made up by more sophisticated hardware and operating software. Thus the student of 1990 is likely to have a much more sophisticated computational capability available than a student in 1980 at about the same cost. If a classroom personal computer is to serve 20 students per day, each receiving 15 minutes of instruction, and the useful lifetime of a computer is 5 years, then the annual cost per student is $15.00. Add to this the cost of the software discussed previously and the costs of

recording media and other instructional materials used by the student and the teacher, the annual cost per student would be somewhere close to $20.00 under these assumptions. As courseware becomes more sophisticated its cost is likely to increase, as has been the experience with software versus hardware cost ratios in industry. Consequently, by the late 1980's or early 1990's cost of software might be exected to equal those of hardware.

Institutional Barriers

There are significant structural barriers to the use of personal computers in school systems. The most fundamental of these are economic. Most education, in grades Kindergarten through 12 is funded by individual states, by local governments and/or by local school districts. From 80% to 85% of the school dollar goes to personnel costs (abvout 50% to instructional personnel and 30% to 35% to support and administrative personnel). The remaining 15% to 20% is used for facilities purchased, maintenance, fuel costs (particularly in areas with extensive bussing programs), and educational materials. Less than 2% of the school district's budget, usually considerably less, is available for all forms of educational computing. Typically, from $.40 to $.80 of every 100 school dollar goes to computing expenditures of all sorts (computing activities in secondary education, 1976). Therefore, under current conditions, the computing expenditure distribution shown in Figure 1-1 would result in roughly $.40 of every 100 school dollars being spent on instructional computing of all sorts. From 1/4 to 1/3 of this, at present, is spent for computer literacy applications in those schools which use computers for instruction.

If 2% of the educational budget were to be spent for computing, as opposed to the 2/3 % of which appears to be typical of the late 70's, then about $770 per classroom might be spent by schools in the United States for computing (about $43.00 per student per annum). The amount available for the purchase of personal computers and associated software to be used in the instructional process would come to about $10 per student per year if the funds were to be averaged over all students in grades K-12. In actuality these figures, although lower than the requirements of the technology previously discussed, are still higher than the recommended expenditures on all forms of educational media in primary and secondary schools. For example, the North Central Association of Colleges and Schools recommends expenditures for books, magazines, and audiovisual materials (exclusive of textbooks and equipment) as $6.00 per pupil in small schools and slightly smaller amounts for larger schools. (NCACS, 1979-2 references). In short, current and forseeable costs of computers in primary and secondary education are such as to equal or exceed the funds available for all such media under current educational budget structures and policies. Furthermore, there appears to be little sympathy among the tax paying public for increased school expenditures, particularly as enrollments in primary and secondary education will generally decline throught most of the 1980's. Consequently, expenditures for computers within existing schools will have to be made at the expense of some other alternative. There seems to be few volunteers stepping forward to claim the budget cut.

One immediate possibility for providing the extra funding is to increase the student to teacher ratio in proportion to the increase in learning productivity brought about by use of personal computers. However, the laws in many states fix the student to teacher ratio. A typical number in elem,entary school is 30 students per teacher, although the actual national average in 1977 was about 22 students per teacher in an elementary schools, 18 in public secondary schools (16 in private schools). (Statistical Abstracts,

1979). Consequently, any improvement in teacher productivity which might be engendered by the use of personal computers would have no immediate effect on personnel costs since the student to teacher reatio would remain unaffected by statute. Thus, even though the amount available for personal computing in schools could be doubled by a 2% reduction in teacher expenditures, this appears to be unlikely under current conditions.

One possibility for alleviating this situation might be similar to the scenario discussed for office workers in Chapter 5: Computers are bought for school systems simply because there are not enough teachers to go around. Strange as that may seem in an era in which school enrollments are declining, there appears to be some factual basis for that possibility. The frequency of reports is increasing, indicating a demand greater than the supply of teachers in local school districts. "The major reason for the dramatic turn around is clear - the number of college students going into teacher training has dropped sharply in the last five to seven years" (McCurdy, 1980). A 1980 survey by the Association for School, College and University Staff (ASCUS) have found that shortages of teachers existed in 23 categories in secondary schools, particularly in mathematics, science, vocational training, and special education - all these areas in which personal computers might be particularly appropriate. In the school districts where this situation exists part of the salaries, now essentially unclaimed due to the unavailability of teachers, might go to the purchase of personal computer software. Since there tends to be a lag between demand for certain types of expertise and the production of that expertise by the educational system, as there is a lag between excess production and adjustment to a diminished market, it is possible that this deficit in elementary and secondary school teachers could increase through the mid '80's or longer if other incentives for new teachers do not develop.

Improvements in learner productivity, which might be significant in some educational situations, such as in industrial, office, and government personnel training, appear to have relatively little effect on the primary and secondary school systems. The performance criteria of the school systems are predicated more on student classroom attendance days than on student achievement. Only in a few states, such as New York, are specific student performance accomplishments major elements of the evaluation of the educational system. In the past, there has been relatively little correlation, or possibility even anti-correlation, between the size of a school budget and the measured performance of its graduates. Here, too, the trend may be reversing as more communities become concerned with rowing signs of basic functional incompetence of graduating high school students. The personal computer could be viewed as an ideal instructional medium in this regard since functional competency criteria tend to be quite objective, hence ammenable to incorporation in personal computer based instructional and testing programs.

Finally, primary and secondary school systems provide few incentives for teachers to use personal computer technology (most of them provide none), even if it is proven to be exceptionally defective in certain learning situations. Since school enrollments will be generally falling throughout the '80's and the rate of production of new teachers has slowed, the averge age of teachers in the school system is steadily increasing. Since many school systems, particularly those in large urban areas, seem to be spending much of their energy in coping with changing ethnic mixtures, declining safety in the schools, and other, survival oriented problems, there are few or no teachr incentives for any type of improved teacher performance. Since very few colleges and universities require computer literacy and teach computer familiarity to students in their education schools, even in 1980, the level of computer literacy among the average teacher in the educational system is

understandably quite low. Thus the typical teacher would have to learn a new and possibly forbidding topic in some detail, requiring a substantial investment in time and effort, with little possibility of additional compensation for that effort, before introducing it into the classroom.

The typical, computer naive, primary or secondary school teacher is at present more inclined to view the personal computer as a competitor for his or her job rather than as a teacher's assistant. This common attitude can be a powerful deterrant to the acceptance of personal computers even if all the other barriers just mentioned were eliminated. Consequently, one of the major immediate tasks put before any one or any agency desiring to increase the rate of diffusion of personal computer technology must be the education of the teachers themselves. This has been the approach taken in France where the President has declared a "Computer in Society Week" and the government plans to install 10,000 microcomputers in secondary schools by 1985 (one for every 73 students, allowing each student 15 minutes of use per week.) (Blumenthal, 1979). "However, what is most likely to occur within the next five years (in France) is that some students will have a few hours use each week and others will have none at all." (Habenstreit, 1980).

Clearly, there are many enthusiastic teachers in primary and secondary schools who are currently busy developing applications of personal computers for their classrooms. However, as a general rule, we do not expect to see a rapid and massive switch to the extensive use of personal computers in primary and secondary schools. This is reflected in the market estimates of Volume 2. One caveat should be injected at this point. Past experience has shown that, once a new educational technology is accepted within the primary and secondary school systems, the rate of diffusion of that technology is very rapid indeed, thus if conditions were to change, or perceptions of conditions were to appropriately change, to encourage the acceptance of personal computrer technology, then most of the primary and secondary schools throughout the United States might have personal computers essentially as fast as the manufacturers could produce them.

Secondary Barriers

In addition to the barriers of insufficient funds, low level of computer literacy among primary and secondary school teachers, asnd low levels of motivation on the parts of those teachers to become computer literate, the situation is exacerabated by the highly fragmented nature of the educatin market. With the exception of a few states in which textbook and educational material purchases are controlled by a state agency, materials are decided upon and purchased by individual school districts or even individual schools. Standards vary widely and the option for local decision as to course content and materials is observed much more frequently than the insistence on area-wide standardization. Even in large school districts, where a large number of schools or students are served by a single administrative unit, the purchasing decisions for educational materials are often price driven (i.e., minimum price at an "acceptable" level of quality rather than maximum quality for a given price). Special hardware configurations and courseware, which generally is developed according to performance criteria expressed by teachers, may not adequately meet the cost performance criteria demanded by the purchasing agents.

Under these circumstances the prospective vendor of educational computer hardware courseware can easily spend significant amounts of time trying to penetrate the maize of bureaucratic procedures associated with school districts without tangible success. As one computer retailer put it "They [the school systems] consume a tremendous quantity of time and never buy

anything". In other comments, referring to the minimum price rule just mentioned, "Even if you've done all the homework and put on all the demonstrations and talked to all of the people, it [the computer system] may get sold right out from under you". (Computer Retailing, 1979).

A possible barrier to the acceptance of personal computers in education, one which will vary as a function of the prior experience of the individual school district and/or staff, is that due to prior disillusionment with computer aided learning. The reason for this disillusionment in the past has been the encouragement by overzealous salesmen of expectations for the capabilities of computer aided learning which have been substantially in excess of the actualities. As has been outlined previously, many public school systems were soon saturated with videotape recorders in preparation for this touted millennium, in the form of wide variety of high quality TV courseware. This millennium has not yet arrived for many of the same reasons just discussed. In the interim, school system purchasing decision makers, viewing the numerous TV recorders gathering dust on school room shelves, may perceive personal computers as yet another empty technological promise. At the present state of development of personal computer courseware it appears that this skepticism is largely justified, at least with respect to the quality of available consumer aided instructional courseware.

3.2 Higher Education

Within colleges and universities in the United States the conditions are similar to those of the primary and secondary school. The claim for expenditures arises primarily from faculty salaries, budgets are declining because of a decrease both in the absolute number of students of college age and in the proportion of high school graduates who go on to college. Although computer literacy is widely taught and reequired in the sciences, mathematics, and schools of engineering and business, it is not generally required in other schools of universities or in colleges, with some notable exceptions, such as Dartmouth. Even in the most computer literate universities, computer aided learning techniques other than those related to computer literacy are not in widespread use (Bork, 1978, Molnar, 1979). The purchasers of the educational services in colleges and universities, the students (or their parents), prefer a low student to teacher ratio, feeling that this provides a higher level of individual instruction. Consequently, arguments which emphasize increased teacher productivity, allowing more students to be effective when served by a single teacher, are not greated with enthusiasm.

In addition to this latter issue, the course content in colleges and universities tends to be less amenable to the use of computer aids. The types of classes in which personal computers would be most effective are those involving basic knowledge acquisition, as is the case in primary and secondary schools. These are topics such as remedial reading (to rectify the failures of the primary and secondary school systems, particularly among minority group students) introductory college mathematics, basic science and engineering courses, economics, etc. These classes tend to be those which are already quite cost-effective. They generally have large student to teacher ratios and are usually taught by assistant professors and graduate teaching assistants, those at the lower end of the college pay scale. The higher paid faculty usually teach courses with much smaller numbers of students. These courses generally involve the teaching of complex topics requiring a relatively high level of interaction between student and teacher, areas in which personal computers, at least at their present and forseeable (over the next decade) level of development, are not highly effective.

Policy Analyses
Education

Colleges and universities share a further characteristic with large business and governmental organizations that have centralized computing facilities: The managers of the computing facilities view personal computers as a threat to their autonomy and resist their adoption by units outside their span of control. This may also be true to some extent in primary and secondary school systems but, in general, colleges and universities are more likely to have centralized computers than are primary and secondary schools except in large urban areas. Interestingly, one of the possible means by which personal computers will be used more widely within colleges and universities is as a consequence of the inability of university computer centers to keep up with the demand for computing time. In order to relieve the pressure for time on large mainframe computers, some university computing centers are beginning to encourage the acquisition of mini and microcomputers for the smaller computing and instructional tasks. The argument is the same as that used in business and government: through the purchase of micro and minicomputers advantage can be taken of the latest technology, i.e. greater computing power per dollar expended, without requiring a massive investment for a mainframe. Thus, even though the raw cost/effectiveness of a state of the art mainframe is invariably higher than that of the state of the art personal computer (as measured in dollars per instruction processed per second), the net effectiveness, in terms of utility of the computer to the user may well be higher for the personal computer. However, these argumenmts are just beginning to appear in colleges and universities although we expect them to increase in frequency and force as personal computer technology improves.

The net result of these barriers is that college and university administrators interested in using personal computer technology as a means for increasing the productivity of higher edumtion run into significant obstacles. In additional barriers to the use of computers in higher edumtin there is a serious supply problem. Colleges and universities have difficulty competing with government and industry for newly graduated computer professionals. A new Ph.D. in Computer Sciences often will be offered a higher salary and greater fringe benefits than are available to most of the faculty who taught him/her. Consequently, there are few teachers available to teach the teachers of computer literacy.

The field of continuing education may hold more immediate promise for applications of personal computers, particularly where the purpose of the continuing education courses is to help prepare students for specific career objectives. In these cases, as in the case of introductory courses at the college and university level, emphasis is placed on acquisition of factual material and the development of basic information manipulative skills, areas in which personal computers can be particularly effective. However, where continuing education courses are developments sponsored by colleges and universities or by adult educatin branches of secondary school systems, many of the barriers which exist within the central operations of these institutions may also act within the continuing educations programs.

In summary, even though there may be significant national goal incentives for rapidly increasing the rate of computer literacy in the United States, and for training more people in computer science technology (see Chapters 5 and 6), the existing institutional barriers, reward structures and financing of the primary educational system, do not appear to be inately responsive to these needs.

3.3 Other Markets

Our own estimates and those of our Delphi panelists lead us to believe that about 60% of education oriented purchases of personal computers and associated software will come from outside the educational community just discussed. Even these estimates may be conservative. Other estimates concerning expenditures for education were made by industry alone, put them at the same level as the entire educational system, in the order of $100 billion per year. (Heuston, 1977). Our panelists estimate that industrial purchases of personal computers for in-plant purposes will be roughly equal to purchases by secondary schools. However, when industrial contributions toward tuition support for employees studying in community colleges, universities, colleges, continuing education and adult educational facilities is included, the larger prediction seems quite plausible. Since we have been unable to find accurate data to support these contentions we conclude that the split of the total educational pie in terms of institutional purchases of personal computer hardware and software might be roughly as follows:

The Educational System (Primary & Secondary Schools, Colleges and Universities)	47%
Industrial In-Plant and vocation-oriented training	33%
Department of Defense	20%

Where the support of external training by government industry, at colleges and universities and other schools, is included under the educational system category our panelists anticipate that an additional 30% of the total amount spent in the above three categories will be spent by consumers for education in the home. Presumably, a substantial fraction of that amount will be associated with concurrent educational activities on the parts of consumers in more formal educational settings.

Unlike the situation in the educational system both industrial and government motivation for the use of personal computers as key elements of the instructional process may be predominately economic and positive. (The term "industrial" in this discussion is used in the broadest sense, encompassing all private sector and non-defense public sector educational activities outside the education system.) Where personal computers are demonstrably superior to, or faster than, more traditional teaching techniques their use can be directly translated into dollar oriented cost/benefit terms, without consideration of the earlier concept of job satisfaction, personal enrichment, etc. As national attention increases concerning issues of worker productivity (see Chapters 5 and 6), the aforementioned virtues of personal computers for simple task procedure training and factual knowledge assimilation will be translated into direct economic terms. In our development of market growth estimates for office oriented computers we considered that training applications would constitute an important aspect of the development of the market.

Personal computers will also be seen by perspective government and district purchasers as a relatively inocuous means for producing office automation technologies into their organizations. Since personal computers tend to be less threatening to computer naive users, in our experience, they provide a means of subliminal training, through the use of games and other, apparent work unrelated, strategems.

Notwithstanding these incentives for adoption of personal computers in

government and industry, some of the same barriers to their adoption exist as are present in the educational system. These include fears of loss of control of software and hardware standards within the user organization, fear on the part of employees that the introduction of personal computers, even if only for educational purposes, may be a prelude to increased unemployment, purchasing decisions based on price rather than value received and similar considerations discussed previously. However, even though these concerns can be real deterents, arguments for, and demonstrations of, increased productivity are likely to dominate in the long run.

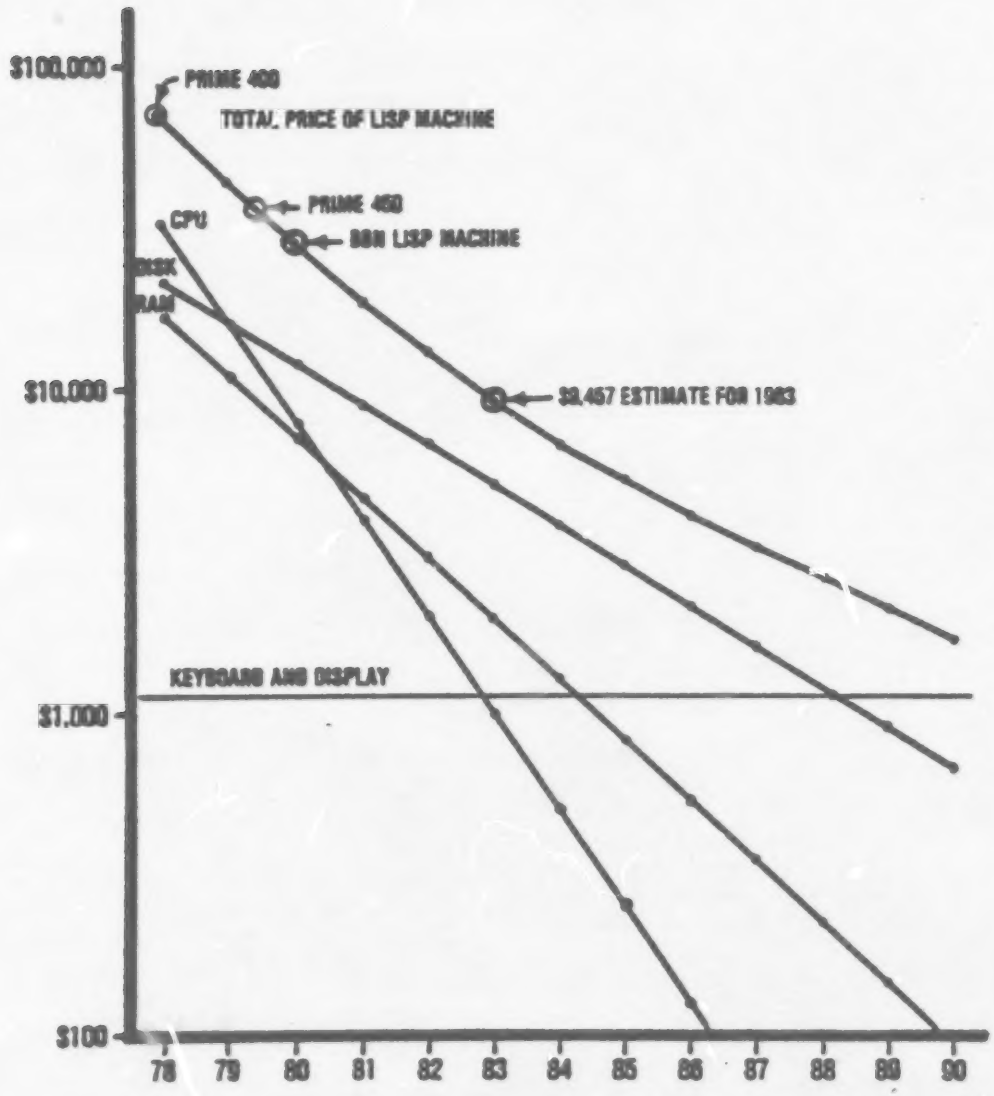
Some of the same technological consideratins that are fundamental to the development of personal computers in the eductional system, are also present in industrial and defense applications. As in the case with the educational system, concerns tend to be centered about the development of appropriate, high quality courseware. For example, Wolfe and Williams predict a total hardware cost for a 1983 personal computer using a 16 bit microprocessor at the higher level language LISP, as just under $9500. (Wolfe and Williams, 1979). Their projections for machine costs are shown in Figure 4-2. The discussion by Wolfe and Williams goes on to list the following specialties for which computer aided instruction might be most appropriate:

Boiler Technician
Data Processing Technician
Electrician's Mate
Engineman
Electronics Technician
Fire Control Warfare Technician
Interior Communications Technician
Machinist's Mate
Operations Specialist
Radioman
Sonar Technician

Excluding the uses of personal computers for basic training in literacy (computer or otherwise). The following rationale is given for hardware purchases: "The conservative assumption is made that prices will not decline after 1988, but will level off to $3000 per machine. Maintenance costs are assumed to be 10% of the initial purchase price, and equipment is replaced after 5 years. The program levels off to $3.6 million a year for a constant inventory of 4000 LISP machines. These figures can be compared with the Navy's total budget of more than $1 billion a year for special skill training, not including Fleet exercises and on-the-job-training. As another comparison, a single training device such as the Navy Electronics Warfare Training Simulator presently costs over $30 million."

Wolfe and Williams go on to assess software costs as high as $5 million per major application. This is an order of magnitude higher than the courseware costs discussed in the section on Primary and Secondary Education but it is still readily justified by productivity considerations (using a amortized cost per student hour of $1.83). Furthermore the type of capability projected by Wolfe and Williams for the LISP machine is considerably in excess of that required for many forms of primary and secondary education.

In parallel with our assessment of personal computer technology we conducted a questionnaire survey of small businesses in the Los Angeles area in an attempt to assess attitudes toward personal computers. Seventy one small business owners responded to our survey. Over 75% of the respondants rated their knowledge about and experience with computers at a low to intermediate level, the majority being at the low level. Ninety eight percent



PRICES OF LISP MACHINE COMPONENTS PROJECTED FROM 1978 to 1990

SOURCE: Navy Personnel Research and Development Center: NPRDC SR 79-16

FIGURE 4-2

were willing to teach themselves or their employees to use a personal computer for business purposes. The average cost estimated by the respondants for a computer suitable for their businesses was just under $16,000, although the average price they would be willing to pay for a business computer in 1979 was $8700. Most respondents overestimated the current cost of personal computers for business use by a factor of 2 or more.

The current gap between the demand for trained engineers and scientists and the supply being produced by universities in the United States is exacerabated by a declining currency of the education received by new graduates, according to Donald Glower, the Dean of Engineering of Ohio State University (Science, April, 1980). "Our graduates are going out into industry not knowing the technology of today. They have been trained the in technology of yesterday," according to Glower. As a consequence the industrial organizations hiring these new graduates find themselves in the position of having to train them in advanced technologies. Personal computers, in our estimate, will gain increasing importance to these firms in their training operations.

Even at the more fundamental level, computer literacy is becoming a minimum requirement. Arthur Luehrman cites the example that current practice at Pacific Gas and Electric Company is that 80% of new jobs in that firm require computer understanding. An applicant with from 10 to 20 hours of hands-on experience is almost certainly hired (Luehrman, 1979).

Continued anecdotal evidence such as the above leads us to the conclusion that, despite the existence of some barriers which are comparable to those in the education system, the industrial and defense market for educational applications of personal computers will be largely market driven. In many cases this market will be larger than it might otherwise be as a consequence of failures of the educatinal system to meet demand for training in computer literacy and other fundamental topics.

Consumer interest in the educational uses will cover the broadest possible spectrum, from astrology to zymurgy. Parents will wish to duplicate or enhance instruction and practice sessions received by their children at school, hobbyists will wish information and practice on their hobbies, from automobile repair, to morse code practice, to typing instruction. Professionals will wish to update their skills at their own pace in their homes or offices. And so on.

The primary barriers to the use of educational technology by the consumer appear to be related to the cost and quality of courseware. These, in turn, are affected by the standards, copyright and marketing considerations discussed previously. For many subject areas, courseware available to consumers will be generally equivalent to that used by the educational system and/or industry and government. In other cases, particularly those involving hobbies and cultural topics such as computer graphics as an art form, computer/electronic music, etc., the market may be consumer dominated.

4 Public Policy Implications

The preceding material, based on the best evidence presently available to the research team, leads to the conclusion that the market process will probably serve quite well for many of the applications of personal computers to education, particularly those that are outside the educational system. Personal computers have a substantial and rapidly growing potential for effective use in a variety of educational applications but, in the education system arena, much of this potential may not be realized unless there is some form of intervention in existing market patterns. The Federal government has an important but often indirect influence on the state of education in the

United States. Many of the direct changes in educational policies and practices occur as a consequence of state and local actions. Consequently, we have treated these as well as Federal policy implications.

4.1 Federal Policy Options

The Federal Government has a variety of policy options and instruments by which it can influence the impact of personal computers on future education. The basic role of the Federal government in education can be viewed as that of a market aggregator, lending order to an otherwise highly fragmented situation. Two aspects of the development of educational technology can be influenced by Federal policy: 1) the supply and quality of educational materials, and 2) the economics of the educational technology market.

Table 4-2 lists estimated FY 1979 Federal Education related expenditures. As the table indicates, the new Department of Education (listed in the table under Health, Education and Welfare), although the largest, is by no means the only big spender among Federal agencies. For example, the Department of Labor spends more on vocational and continuing education than does the Department of Education on either primary and secondary schools or higher education. The Veterans Administration spends about 40% as much as the Department of Education on higher education, through various GI Bills. Total Federal Expenditures for education in fiscal year 1979 were estimated at just under $31 billion, according to the U.S. National Center for Education Statistics. Of this amount, $9 billion went to higher education institutions, $6.5 billion went to elementary and secondary education institutions, and $6.3 billion went to vocational and technical schools, all in the form of grants. Clearly, the Federal Government has a vital economic role in the support of education within the United States.

The most fundamental role is played by Federal support of basic and applied research and development of educational technologies and courseware. Estimated FY '79 Federal Expenditures in this category were $5.4 billion. This support ranges from basic research on cognitive processes (that is, understanding the ways in which different people think and the relative effectiveness of various techniques for teaching), to the development of specific "courseware" for teaching well-defined subjects. Because the development of courseware for computer aided learning is highly labor intensive, it is important that the best qualified teachers and instructional technologists be used and/or that sophisticated course development software be developed as an aid to the courseware authors. It would appear from our research that the costs of courseware for general education under forseeable market conditions would at least equal hardware costs for a well developed computer assisted learning curriculum in 1990. Our Delphi panelists felt that funding for this development effort is unlikely to be supported solely by the Federal government. If traditional paths are followed, the Federal role would be to support the critical core efforts, particularly in basic research in cognitive processes, and development of prototype courses in a variety of fields, so that broader developments could be undertaken by the private sector. In his summary of the ideas presented in "Technology and Science Education: The Next Ten Years - Perspectives and Recommendations," Lipson states:

> We need to make explicit what is meant by such ideas as "understanding," "common sense reasoning," and "tacit and intuitive knowledge." What is the difference between the way a novice organizes and uses knowledge and the way the expert does it, when each is faced

FEDERAL EXPENDITURES FOR EDUCATION

FEDERAL AGENCY	ESTIMATED FY 79 EXPENDITURES ($MILLION)			
	PRIMARY AND SECONDARY SCHOOLS	HIGHER EDUCATION	VOCATIONAL CONTINUING EDUCATION	OTHER
Health Education & Welfare	5400	5424	278	546
Agriculture	121	12		2958
Commerce		5		16
Defense	383	1	3	836
Energy		3	1	
Housing & Urban Development	2	52	1	
Interior	396	40	60	
Justice		35		
Labor			5552	
State	9		2	
Transportation		1	17	30
Treasury			14	
Other Agencies				
Appalachian Regional Development Commission	32	3		
National Science Foundation	3	28		
Veterans Administration	66	2008	391	63

Source: National Center For Educational Statistics

TABLE 4-2

> by a similar problem or task? How does one's world view affect the way a decision or problem is attacked? In order to build a computer-based learning environment that is appealing, significant, and effective, we need cognitive theories (i.e., theories of complex human thinking) that have a degree of completeness, precision, and specificity unprecedented in psychology educational theory. Thus, the attempt to build a computer-learning environment forces us, first, to be serious about cognitive theories, and second, to use the learning environments we develop as test beds for the theories. (Lipson, 1980).

Clearly, a fairly substantial amount of development of computer assisted learning courseware can proceed with our existing body of knowledge, particularly developments which convert courseware from older, larger computers to microcomputers. Nevertheless, for the long term it appears that this fundamental research is keyed to future developments. In general, such research is likely to be supported primarily by the Federal Government. The research should not be confined to the learning processes of children. Adult learning should also be investigated since many of the applictions of CAI will be adult oriented.

Coupled with the research on cognitive processes, and development of pilot CAI and other computer based learning programs, might be a series of longitudinal surveys of the effectieness of such programs. Our Delphi Panelists indicated that positive results from experimental programs validating the effectiveness of computer based learning would have substantial impacts on both home and educational system uses of personal computers. Such demonstrations would have additional leverege in that they would stimulate independent production of courseware by individual teachers and by educational publishers. On the other hand, the general development and distribution of low quality and/or trivial courseware could have equally great, and possibly longer lasting, negative effects.

In addition to its role as supporter of various forms of research and development related to the production of improved courseware the Federal Government also has a role of developing hardware technology. The foremost among the immediate prospects for research is the use of videodiscs and mass storage technologies for use with personal computers. There are two basic technological objectives in this area. The first is to develop, or promote the development of, high-density, low-cost, high-speed memory (one megabit RAMs, for example) to support high speed, multicolor computer graphics and large courseware packages. The other focus might be on the development, including system integration problems, of videodisc or other (as yet unidentified) high-density secondary storage technologies. These developments must occur concomitantly with the courseware developments.

For all of the development areas just listed, particularly at their present, initial stages, it seems clear that Federal support is required. The market is not yet well enough defined, apparently, for substantial private sector investment to occur. However, this Federal role, although necessary, may not be sufficient. The developed materials must be useable by a variety of institutions, using a variety of personal computers.

This further requirement leads to a necessary accompaniment to the Federal role of research and development support: leadership in the development and coordination of uniform standards and guidelines for the computer-based educational materials. Two types of standards are of greatest importance: 1) those relating to minimum acceptable quality of developed courseware, and 2) those requiring a high level of transportability of developed courseware among a variety of potential computer systems. The

latter element is of particular importance when one considers that a typical complete one-year course suitable for use on a microcomputer may cost anywhere from $100,000 to several million dollars (including marketing and distribution costs), depending on its complexity, number of options available, extent of interactivity, etc. At the present, diversified state of the personal computer industry, there are very few computer applications programs which are useable with large numbers of different computers.

As an example of the present situatin, Apple Computer, Inc. is marketing their microcomputer and associated software to the educational system through an agreement with Bell and Howell; Atari has contracted with Dorsett Education, Inc. to develop educational software for secondary education systems; Milikin Publishing Company is marketing mathematics and other instructional software packages which may be used with the Apple II, Pet, and TRS80 microcomputers; Texas Instruments has announced a relationship with Scott Foresman Publishing Company. Presumably using the latter's educational software development and marketing capaility. (Microcomputer Education Applications Network, 1979, 1980). Although one of the same publishers just mentioned is marketing different versions of the same software, usable on different personal computers, in general it would seem more logical to assume that individual hardware manufacturers might strive to insure that the courseware produced is compatible only with their own machines, thus limiting transportability.

If transportability is not achieved, then it would be necessary either to develop uniform equipment standards (generally by fixing them at present levels of development, which might seriously slow the rate of technological development of the hardware), or to allow one or two companies to dominate the education market. The latter action, or consequence of a failure to take action, would result in the creation of a de facto monopoly (or oligopoly) position to achieve software transportability.

Quality standards and guidelines can be at least as important as those relating to transportability of developed materials. The development of high quality courseware requires substantial investment in expensive, scarce resources: imaginative and accomplished courseware authors. Economic considerations would generally lead to emphasis on the development of courseware at "acceptable" level of quality for the minimum cost, particularly if the publisher were not considering a mass market for the product. The exparience with television programming leads us to conclude that there is a high probability that courseware developed for mass markets would be trivial or of relatively low educational value. Unless minimum standards are adopted by some organization with a major influence in the educational market. This need not necessarily be the Federal Government.

In addition to the role of development of versatile, transportable, high quality educational software, there appears to be a Federal role in evaluating the broader consequences of the uses of educational technologies. As mentioned earlier, educational technology, however effective it may be, may only have an influence on the breadth or incremental rate of learning of children. Motivation, "readiness," and other external factors may play a significantly greater role. Nevertheless, computer aids to education may be particularly effective in some educational modes. A Federal role could be to develop evaluation standards and support longitudinal and other studies to assess the relative effectiveness of various approaches (as contrasted with the CAI effectiveness studies discussed earlier). In this way emphasis can be placed on maximizing benefits - or minimizing disbenefits - of the technology over the long term.

One critical factor in the rate at which the private sector may assume the long term responsibility for development of low cost, effective,

transportable educational materials is that of patent and copyright protection. As stated elsewhere in this report, there is, in practice, essentially no existing effective means for the protection of the property rights of the creator of computer software. There is even considerable uncertainty as to whether the software creator has property rights in his/her creation. This issue is a serious one in many aspects of the applications of personal computer technologies but may be particularly critical for educational applications. Even under existing law for printed educational materials the "fairness" doctrine limits copyright protection by allowing extensive, royalty-free copying of educational materials by schools and teachers. The prospective publisher of courseware is thus faced with the prospect of recovering his investment with a very few, rather than thousands of sales, (and unrenumerative to the publisher) copying. This presents a situation entirely counter to the concept of market forces being primarily responsible for low cost personal computers.

Federal actions can also play a direct economic role in the rate of growth of educational personal computers. First the government can directly purchase personal computers for distribution to various school systems and for its own use (for example, by the Department of Defense. A more likely role for school support, however, is that of Federal support of personal computer hardware and software purchases through various education aid programs, such as Title III of the Elementary and Secondary Education Act (ESEA). The government can also indirectly influence purchase through mandated procurement, in which Federal support of certain education programs may be contingent upon purchase by the recipient agency of educational personal computers. To be most effective, either version of this support should be accompanied by the standards considerations just discussed. This procurement support might be general or specificially directed toward alleviating some of the equity issues discussed earlier. Possible techniques might include support of PC packages in minority area schools and libraries, specialized training of teachers in those areas and the development of special, minority directed curriculum.

Finally, the government plays a major role in development of educational policies at other levels through its widespread information dissemination activities. Two such activities have been under consideration in Congress. These are: HR 3822, which would amend Title III of the ESEA to establish a National Center for Personal Computers in Education, and the broader scope HR 4326 to establish a national commission to study the implications of information technologies in science and technology education. HR3822, which is currently dormant, would establish a single national center and, ultimately, several regional centers which would act as clearinghouses and as centers for development, demonstration, and testing of courseware and personal computer systems for educational purposes. Although this Center appears to be an excellent idea, the Select Committee on Education did not even schedule hearings for the bill. The purpose of HR4326 was to study the implications of information technology over the next 20 years with emphasis on "The Effect of Such Technology On Education and Lifestyles." The study would include forecasts of requirements for computer literacy, effects of computers on school financing and taxation, means of increasing private sector involvement in computer related education, and cost benefit analyses of training teachers in the use of computers. Although hearings were held, the bill is not being pursued sinde, in the interim, the Department of Education was created and the sponsors of the bill felt that the study might be more appropriately performed by the new department. The Department of Education is likely to have a major role in the dissemination of information concerning the potential capabilities via the Assistant Secretary for Educational Research

and Improvement. Other Federal information dissemination roles include continuing support of regional and/or personal computer-oriented information centers such as the Northwest Regional Educational laboratory.

The critical point to be made here is that the development of quality educational technology for microcomputers is expensive and consumes scarce resources (independent educators and computer programmers). This can easily develop into a continuation of the cottage industry situation, replete with small entrepreneurs (individual teacher programmers), none of whom has sufficient staff to create truly competent courses. Federal Policy as developed and promulgated by a number of agencies, can act in this situation to provide some integrative influence without stifling the competition necessary for the creation of innovative programs.

4.2 Non-Federal Policy Options

Non-Federal public agencies, private groups, and individuals can influence the rate and character of the diffusion of personal computers in education. In addition to support of research and development, information dissemination, and procurement alternatives, similar in nature to Federal options, there are some specifically non-Federal options.

The most central of these state and local options involves teacher training and motivation. Unless the great majority of teachers learn to treat personal computers as useful aids rather than threats to their jobs, personal computers are not likely to be used extensively in public school systems. Furthermore, unless teachers are trained to use personal computers effectively, they will not materially alter the educational results: the depth, breadth, and quality of education provided our children. Finally, the de facto objectives of the school system must be changed from "babysitting" to maximizing the performance results of an educational process carried out over a period of 12 years. Otherwise, it is not clear that personal computer technology will have a major effect on any but the brightest students.

The broad acceptance of personal computers in education also depends on accreditation. In general, the accreditation process is a reactive one; school curricula, course contents, etc. are developed and evaluated by state, local and/or regional accreditation committees for adequacy and suitability. The accreditation committees do not dictate curricula, courses, or technologies used by the schools desiring accreditation. However, if individual schools and/or school systems using personal computers are given recognition for that use in their accreditation, the expected result would be a more rapid rate of diffusion of the technology throughout the country.

The rate of diffusion of personal computer technology will also be affected by pressure from interest groups outside the direct operations of the school system. These groups include paren teacher associations, industry spokesmen (as prospective employers), and individual concerned parents. For example, interest in, and access to, educational use of personal computers is quite high in the San Francisco Bay area, the home of much of the microelectronics industry. This is also true in the State of Minnesota, where there is a well developed consortium for educational computing, and in Michigan, where there is program for dissemination of information on personal computers to the educational community. One of the questions in the Second Round of our Delphi Survey addressed the issue as follows: General public ownership of PC's exceeds 75%, therefore, the educational system is forced to make use of them. Our panelists felt that the earliest time such an event might occur would be in the 1980's, with the most likely time around 1990. The key factor tending to make this scenario possible would be the reduction in cost of an educationally competent personal computero that of a

TV set. However one of our panelists was more optimistic, stating "This is backwards. I feel that this time education is leading the way . . . .first exposure [of children to personal computers] is occurring in schools" however, active as the protagonists of personal computers within the education system may be, their influence is not yet generally felt. In fact it appears that, unless policies in the traditional "educational establishment" change, these external interest groups may have the greatest influence among all the possibilities for increasing the rate of diffusion of personal computer technologies in education.

Finally, of steadily increasing popularity in a number of states, is a set of alternatives to the public education system as it exists today. If, and as, quality software for inexpensive personal computers becomes available, adult learners and parents may opt for a return to the home as the primary learning environment for themselves and/or their children. One consequence of this scenario would be decreased use of existing school facilities. Since enrollments in Kindergarten through college are expected to decrease anyway in the 1980's, this would put further pressures on school budgets.

Another possibility often mentioned is the voucher system. In this system, which has been discussed for decades, individual parents would be given vouchers worth a fixed amount by their state or local school boards. The parents would then be free to "spend" these vouchers at educational institutions of their choice. The voucher system is also claimed to have a major influence in increasing competition between educational systems. To the extent that this competition would increase the quality of education, force general curriculum updating, and put greater emphasis on the production of results rather than babysitting children, the voucher system could win the votes of many concerned parents. Through the curriculum updating process there would likely be a consequential general increase in the use of personal computers in education. However, the voucher system also has great potential for negative results. It can be used to resist school integration. It may result in even greater fragmentation of the education market, causing further inefficiencies in the development of education and educational technology. Nevertheless, it is clear that public pressure will increase to explore alternatives such as these if the existing educational establishment does not mend itself.

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CHAPTER 5:
THE PERSONAL COMPUTER AND EMPLOYMENT

1. Background

The economies of the United States and the other developed countries in the world are information dominant. About half of the labor forces in these economies are engaged in information processing of one sort or another. Consequently, any new information technology is likely to have a material effect on the nature of the economy and the balance between its factors of production and consumption. Personal computers, as the embodiment of a continuing reduction in cost and improvement in capability of computer technology can, therefore, be expected to have a major effect on the information economy. Or so the theory goes.

Displacement Mechanisms

There are a number of ways in which the introduction of personal computers into the workplace can affect employment. A "simplified" flow chart of some of the alternatives available within a single company or agency is given in Figure 5-1. Personal Computers can:

1. Eliminate jobs by automating them
2. Create jobs by allowing new functions to be performed which otherwise would have been impractical
3. Alter jobs by increasing (or decreasing) their value and information manipulation power.
4. Have no net effect.

As Figure 5-1 intimates, within an organization of reasonable size it is quite possible that each of the above will be the case in some portion or another of the organization. These substitution or augmentation consequences of the introduction of personal computers can occur within single units of an organization, within the entire organization, between organizations in an industry or sector of the economy, and within the entire economy. Although the question of job alteration, changes in job satisfaction, and job variety or stultification are of great interest in our office automation research, the primary near term concern of most of the major stakeholders in employment issues is the basic question of employment: will personal computers result in more or fewer jobs?

The basic considerations are shown in Figure 5-2. As the cost of computer technology decreases and as its versatility increases, personal computers will become increasingly able to take over routine information processing tasks which are now performed by people. The basic decision by an organization's management is an economic one, although it may be tempered by non-economic considerations. The basic economic consideration is that the cost per unit capability of personal computer hardware is decreasing at an annual rate of from 20% to 30%, in real terms. Personal computer software costs for many routine office functions are now, and will be, decreasing at a rate comparable to that of hardware as the software becomes available via mass distribution techniques. This is particularly true for financial and text processing software. At the same time, the cost of labor to perform information processing functions is rising in real terms at an annual rate of

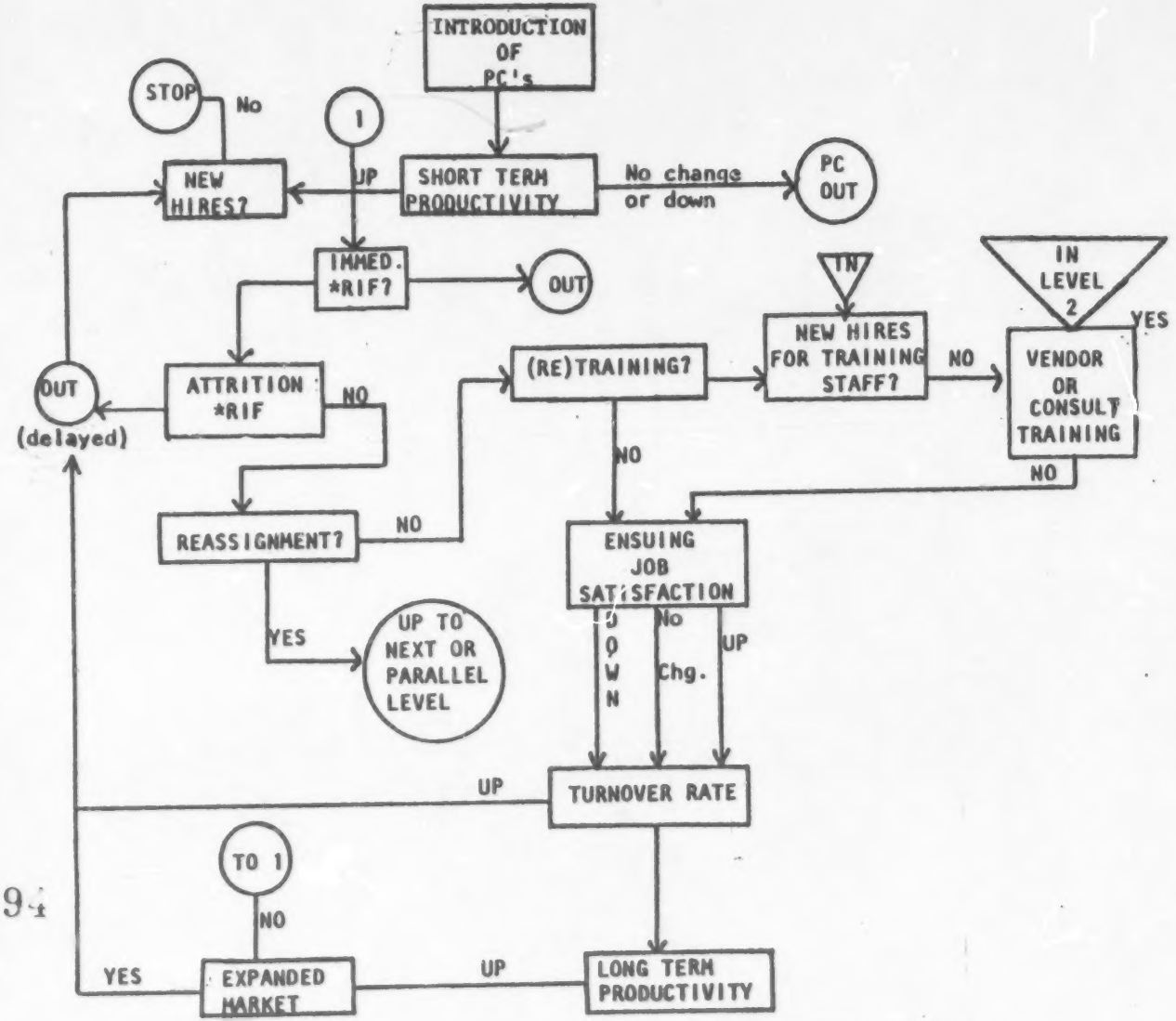

FIGURE 5-1
JOB DISPLACEMENT DYNAMICS

POSSIBLE LEVELS

1. Intraorganizational (shown here)
2. Interorg/but Intraindustry.
3. Cross Industry.
4. Extraindustry.
   (e.g., reduction of home service worker demand thru do-it-yourselfism)

TYPES OF CONSEQUENCES

A. Nonzero (Pos.) Sum

1. Productivity, Profitability and market size increase.
   - net new jobs
2. Net increase in job quality.
   - reduced anomie (increased?)
   - Increased interest

B. Zero (or negative) SUM

1. Net increase in mal-, under-, unemployment.
2. No net change.
3. Increased anomie, dissatisfaction

*RIF - REDUCTION IN FORCE

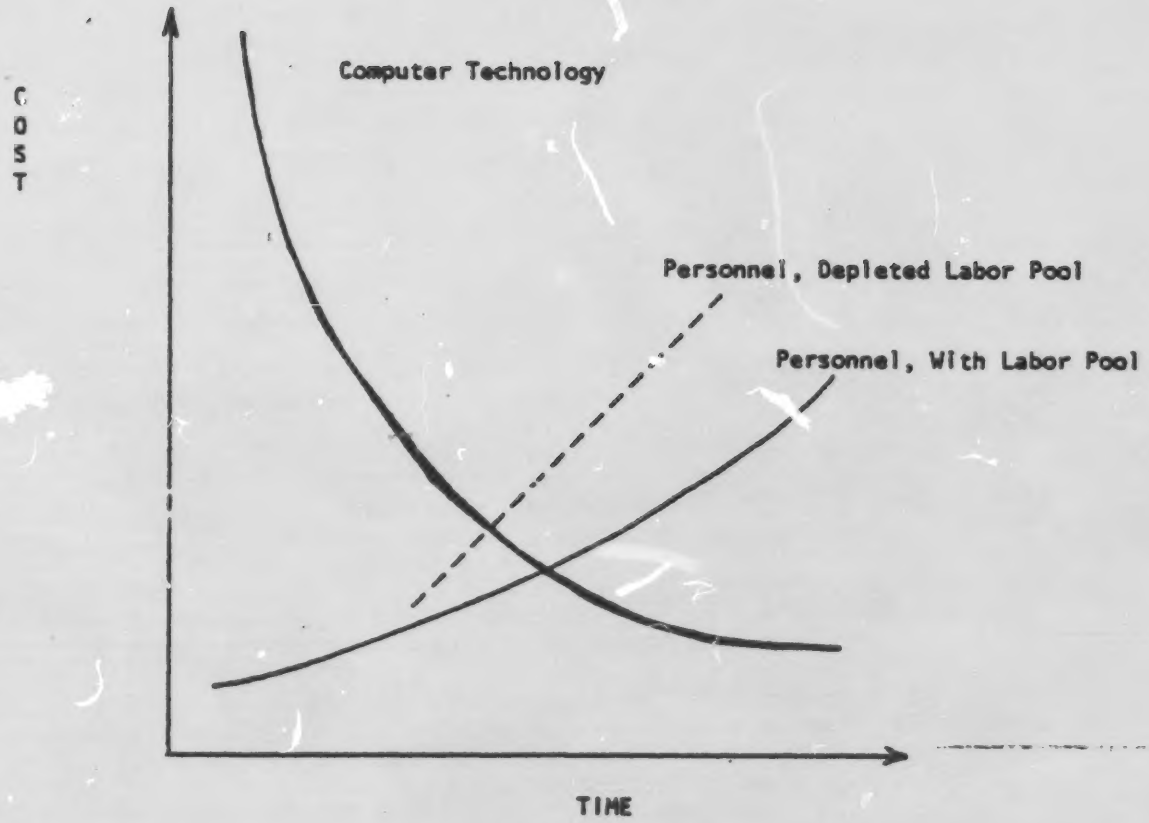

FIGURE 5-2 BASIC ECONOMIC CONSIDERATIONS

from 6 to 15% or more. This increasing labor cost is generally unaccompanied by increases in productivity. Productivity may even go down if the increases in expenditures go to the hiring of new, untrained workers. Traditionally, productivity increases primarily as a result of the introduction of better technology.

At some point, where the cost per unit capability of the personal computer becomes sufficiently low relative to the same cost for a human worker, the personal computer will replace the human and the human worker will be displaced. Whether or not this displacement results in unemployment depends on the structure of the firm and of the industry, the ability of the individual worker to adapt to a different job, the existence of a demand for new types of jobs which cannot be performed by computers, and similar factors. Thus the worker displaced by a personal computer may be fired immediately, may be "invisibly" fired (that is, when the worker leaves for some other reason he or she is not replaced), may be "hang fired" (that is, moved to a similar job in a unit of the organization which has not yet acquired personal computers but which will in the future), or may retrain, or be retrained, for a new job.

Aside from these specific direct employment effects of the introduction of personal computers, there are broader forms of unemployment which may be partially attributed to the use of personal computers. These are:

1. Structural Unemployment - in which available jobs require skills not possessed by available workers, or other mismatches, such as of location, occur.

2. Capital Deficient Unemployment - in which local industry uses obsolete or inefficient equipment and therefore cannot compete in the market, experiencing net loss in income and jobs, and

3. Demand Deficient Unemployment - in which there is insufficient demand for the product being produced by the organization, whether the product is machine screws or information.

There appears to be a reasonable amount of structural unemployment at present in information work. A recent spot check of the classified section of the Los Angeles Times showed that, of 5,000 advertised job openings, 75% were for information workers. Twenty three percent of all openings were for secretarial and clerical workers, including 1% of the total for word processing specialists. Structural unemployment provides an increased incentive for employers to attempt to automate the information processing functions for which structural unemployment exists. This factor, shown in Figure 5-2 as the dashed line, would tend to cause an increased rate of diffusion of the information technology.

Capital deficient unemployment in information industries might be caused by the inability of small firms to attain levels of automation adequate to compete with larger firms. In these cases, personal computers, because of their lower cost for the same capability as older, larger machines, may act to increase employment by making the smaller businesses more competitive.

Thus, it can be seen that there are a number of plausible mechanisms by which personal computers may be used to displace human workers in existing information jobs. (Many observers, particularly in trade unions believe that microelectronics also have great potential for displacing blue collar workers, or converting them to white collar workers, via robotics and other forms of manufacturing automation.) Personal computers also, because of their ability to take on the more routine and tedious information processing tasks, provide

a variety of opportunities for employment which would not otherwise be available. This has been repeatedly demonstrated in the past, with larger computers, in the science and engineering professions. Many recent technological achievements, including the developments of microprocessors and personal computer technology, would not have been feasible were it not for the prior existence of computers. The electronics industry, which has the highest employment growth rate in the U.S. economy (more than three times the national average) further demonstrates this relationship. The fundamental question is whether these positive net employment effects of the introduction of computers will hold for other sectors of the economy as well.

2. Overview

The literature on the social and economic consequences of electronic data processing does not make the personal (or micro-) computer a specific object of attention. Rather, if any differentiation is made, reference will be specifically to large mainframes or to microelectronics. Less frequently, minicomputers are the specific focus of attention. However, it is very rare for any literature on the consequences of computers or electronic data processing to specifically refer to the personal computer.

As a consequence of this pervasive absence of attention, estimation of the employment consequences of personal computers becomes extremely difficult. In this section of the report, then, the discussion will often deal with more general impacts of computers or microelectronics, or with employment matters which provide a context for the consequences of personal computers. The most general conclusion of this section is that the employment consequences of personal computers are largely inseparable from, or indistinguishable from, the employment consequences of other technological innovation. Few if any policy issues unique to personal computers can be identified. Few, if any, policy responses specific to personal computers can be designed. Nonetheless, the question of the employment consequences of personal computers has been a useful vantage point for insight into employment policy in general.

The predominant concern in the literature is with unemployment as a consequence of computers and microprocessors. However, in order to determine the policy implications of computer-caused unemployment, the employment situation in comparative perspective must first be considered. Then, applications areas for personal computers and related technologies can be explored, and estimates of job loss or gain reviewed.

Barriers to applications development and utilization are outlined; these can moderate substantially the impact of computers. The impact of computers on the nature of work is then projected. Finally, the political behavior of the unemployed is reviewed in order to establish some political feasibility dimensions to the discussion. In terms of policy relevance, it is not clear that the employment consequences of personal computers require attention apart from the similar consequences of any technological, social, or economic change. A variety of policy issues other than those of direct job loss, and generally associated with broader technological change, are outlined in the Summary Report based on this review. These broader issues include Federal responsibilities for the establishment of data resources for employment policy; the possibility of a labor-surplus economy and its implications for computer applications; and worker involvement in the mitigation of disruptive consequences of technological change.

3. The Environment of Employment

In this first section of the review, employment and unemployment

generally are reviewed in a comparative perspective involving industrial economies in general. The purpose here is to provide a context for understanding the small movements which might be attributable to the personal computer. Of necessity, this is an intellectual as well as economic oddysey. The policies pursued to cope with unemployment are also part of the environment of employment for this study.

If these policies are ineffective or without credibility in general, then they cannot be recommended to government as responses to the employment consequences of personal computers. Likewise, the consequences of computers must be understood within the wider socioeconomic context of equipment. Certainly, government's role is affected depending upon whether computers augment or mitigate an existing trend.

What we find, in general, is that all industrial countries face common problems of employment and unemployment, and that personal computers are not likely to make much of a dent in the major trends. But ever were they to do so, the U.S. lacks anything like an employment policy in other than a simple aggregate demand sense, and existing theories of job development and unemployment are either intellectually discredited or implemented in the political world in ways that defeat the intellectual core of the theory.

With the major employment trends reflecting long-term demographic and other factors quite independent of such technological innovations as personal computers, global recommendations are out of place in this study of employment. Rather, the concluding recommendation for this section is for government to eschew policy interventions which, in the name of helping technologically displaced workers, instead encourage both younger and older workers to retreat from the labor force.

3.1 Employment in Comparative Perspective

The major policy-relevant concern involving personal computers is the job loss which may be consequent upon their widespread use. In Europe, the trade unions have offered estimates of job loss from microelectronics which are striking: thirty percent or more in some service industries over the next decade. Were these projections to be realized, the attendent social disruption would clearly be a matter for governmental concern even if the jobs were matched by new jobs in other industries. As a prelude to an appraisal of the policy implications of massive job loss or displacement, however, some discussion of employment and employment policies will first be undertaken. For it is far from clear that current policies and the theories upon which they rest are adequate to the problems at hand or foreseeable.

Full employment, economic growth, and price stability have been avowed goals of the governments of most industrial countries since the great depression of the 1930s. In the past decade the possibility of each of these goals has been questioned, and the wisdom of growth itself has also been doubted. Price stability has appeared particularly elusive in the United States during the 1970s. Full employment has been found not only difficult to achieve but difficult to define. And, most seriously, the policies pursued in the name of employment creation have been increasingly found lacking, either because of ineffectiveness, or because of undesirable side effects.

In this section, employment in developed industrial countries will be reviewed. The unemployment problems of the 1970s are projected as moderating in the 1980s as demographics change. The shift from secondary to tertiary sectors seems likely to continue, with due recognition to J.I. Gershuny's analysis of the unreliability of these distinctions in Beyond Industrial Society. (Gershuny, 1978) Labor force participation rates seem to be declining in some countries in spite of the widespread increase in the participation of

women. Early retirement, extended schooling, and more liberal disability benefits combine to lower the labor force participation rates of men. Unemployment itself is unevenly measured due to the substantial distortions introduced by registration requirements, a lack of meaningful standardization for temporal comparisons, and the existence of unemployment benefits offering high net wage replacement percentages. Youth are kept from the labor market by inadequate training and socialization for work, by high minimum wages, by wage and benefits costs that make capital equipment more attractive than hard-to-release workers, and by a pessimism about future economic growth. Unemployment rates for the elderly are low in the U.S. compared to those for younger workers, and are not as far out of line with rates in other industrial countries as the general U.S. rate usually is. Labor force participation for older workers, specifically for older males, has been declining sharply. While health is often given as the reason, retirement benefits, and other economic options (such as increased female employment) seem more likely explanations. In the U.S., in spite of high measured unemployment rates, immigrants, legal and otherwise, continue to find employment in large numbers, often in jobs which citizens find less attractive than the benefits also available. A variety of factors combine to make work unattractive, and new job creation uneconomical in the face of current uncertainties.

3.1.1 International Trends

Using a four-sector model of a national economy, Sabolo (1975) projects steadily growing unemployment from 1960 to 1990 in almost all of the thirteen world geographic regions. However, he sees the unemployment growth which characterized developed countries in the 1970s reversing in the 1980s. In his model, for developed countries, growth will occur in sector III, services and finance. Sector IV employment will remain unchanged, and the other two sectors will decline. The proportions for 1980 and 1990 are given in Table 5-1.

TABLE 5-1:
Proportion of Employment in Each of Four Sectors,
Developed Countries, 1980 and 1990

Sector:		1980	1990
I	Agriculture	16%	11%
II	Manufacturing, Mining, Energy, Transport	30	28
III	Services, Financial Institutions	31	37
IV	Construction, Commerce, other	23	23

Source: Sabolo, "Employment and Unemployment, 19601990" International Labour Review 112:6 (December 1975).

The projections are rather highly aggregated, yet fit with widely disseminated notions of shift from secondary to tertiary sectors in industrialized countries, and the declining birth rate in these countries. Sabolo's projection of unemployment as a worldwide problem helps place American problems in a wider perspective.

3.1.2 Labor Force Participation Rates

It is sometimes assumed that the unemployment problems of developed nations result, at least in part, from an increase in labor force participation. American participation rates are considered historically high, and are usually assumed to be rising. Female labor force participation rates in the U.S. have been increasing, and male rates decreasing. The situation is similar in some other industrial countries, but hardly in all. Table 5-2 provides data on nine countries.

TABLE 5-2
Employment Ratios and Trends in Nine Industrialized Countries, 1970 and 1976

COUNTRY	1970 - 1976 Range	TREND	COMMENT
Sweden	61 - 64%	up	female up, male down
Japan	64 - 61%	down	male and female down
U.S.	56 - 58%	oscillates	female up, male down
Great Britain	57 - 59%	oscillates	
Canada	54 - 58%	up	female up, male down
Australia	60 - 59%	down(?)	female up, male down
France	56 - 54%	down	
German Fed. Rep.	56 - 52%	down	female up, but*
Italy	46 - 44%	down(?)	

Note: *But females also have increased their participation in education, so that the effect on employment is contingent

Source: Adapted from Joyanna Moy and Constance Sorrentino, "An Analysis of Unemployment in Nine Industrial Countries," Monthly Labor Review 100.4 (April 1977)

Given the possible moderating effect of the 1974-75 recession on labor force participation, the data in Table 5-2 suggest that labor force participation rates may not be increasing in the 1980s in industrial countries as a general phenomenon, but that women are in many countries increasing their participation in the labor force. David H. Freedman associates this with economic, political, insitutional, and psychological factors: the growth of the service sector, the growth of government, greater opportunities for part-time work, and the heightened career and occupational aspirations of women. (Freedman, 1978)

3.1.3 Employment and the 1974 Recession

The recession of the mid-1970s brought into relief a number of salient characteristics of employment in industrial countries. For example, France, Great Britain, Germany, Italy, and Japan all experienced a sharp reduction in average work week during the recession, while the U.S., Canada, and Australia did not. The former group of countries all have benefits for partial unemployment, while the latter do not, allowing the former to avoid layoffs during economic downturns. (Moy and Sorrentino, 1977). Such a policy, designed for cyclical fluctuations, might cushion technological displacement if implemented in a disciplined manner. Another feature of the recession in

European countries was the unwillingness of "guestworkers" to repatriate even when displaced from employment. Moy and Sorrentino note that benefits in the host countries are generally better than benefits in home countries, and that guestworkers may fear that new immigration restrictions would prevent their return once they repatriated. The U.S., Australia, and Canada have traditionally encouraged immigration and extended citizenship opportunities for employed aliens, rather than allowed the growth of large "guestworker" populations. However, during the recent recession, both Canada and Australia tightened immigration restrictions. (Moy and Sorrentino, 1977). The lesson for U.S. employment policy is clear: immigrant workers are an integral part of employment policy. The unwillingness, or perhaps inability, of the U.S. government to restrict Latin American immigration indicates that the coordination of employment and immigration policy is politically unlikely in the near future.

The concentration of women in the service sector, and their relative underrepresentation in goods-producing and construction industries, protected women in eight of the nine countries studied by Moy and Sorrentino. However, as women move increasingly into the manufacturing sector, their cyclical vulnerability will increase. Their vulnerability to technological displacement, however, is a more difficult matter to assess. The point here is that major factors affecting employment stability may not all have effects on women that are in the same direction: sometimes women are advantaged in general adversity.

3.1.4 Youth Unemployment

The status of youth in industrial labor markets appears to be deteriorating on a wide front, and for a number of reasons. In general, notes Dun's Review, European employers are reluctant to take on new workers of any demographics because of the cost of social insurance contributions and the burden of new legislation making firing ever more difficult. According to this article, experienced workers are more readily available now than they have been in the past. European industry prefers them to new workers, but prefers also to invest in capital-intensive, labor-saving plants due to both the high cost of labor and pessimism about future growth. Also, recent increases in minimum wage make youth unattractive as trainees. In many European countries, it can be noted, industrial wages and benefits grew very rapidly during the 1970s. While the demand side of the youth employment market in Europe is not encouraging, the supply side is no more attractive according to this analysis. Youth reject many jobs on the basis of pay or job conditions; there is a surplus of college educated youth; youth are often trained for jobs that do not exist and untrained for vocations where employees are in demand; youth prefer to extend their studies or go on unemployment. Freedman projects continuing youth employment problems due to "lack of skills, inadequate training or counselling, the difficult transition from school, insufficient work experience, poorly defined career planning, loose labor force attachment, etc." (Freedman, 1978). Similar generalizations might well be made about the U.S. The employment aspects of the transition from youth to adulthood are no longer taking care of themselves. Whether this is a matter for government attention depends upon one's views on government's contribution to this situation and upon whether one views deleterious public policies as capable of being reversed or worth being reversed.

Statistics indicate that the American youth employment problem, however seriously it is viewed in the U.S., is not of a magnitude, relative to American adult unemployment, that distinguishes it from youth unemployment elsewhere. Table 5-3 displays major increases in youth unemployment rates in

four European countries.

Table 5-3
Youth Unemployment Rates in Four European Countries
1973 and 1977

Country	Unemployment Rates for Persons Under Age 25	
	1973	1977
France	2.9%	11.7%
German Fed. Rep.	1.0%	5.4%
Italy	12.6%	23.8%
U.K.	2.9%	14.1%

Source: Adapted from John Evans, The Impact of Microelectronics on Employment in Western Europe in the 1980's op. cit. p. 105.

Moy and Sorrentino note the same worsening of the relative position of youth in Canada as well; but they do not find it in the U.S., Australia, or Japan. (Moy and Sorrentino, 1977). The 1974 ratios of youth to adult unemployment rates are given in Table 5-4.

TABLE 5-4
Ratio of Youth (ages 16 - 24) Unemployment Rates to Adult (ages 25 - 54)
Unemployment Rates in Eight Industrial Countries, 1974

UR_y / UR_a (approximately)	Countries To Which This Ratio Applies
2.5	Japan
4.0	U.S.A., Canada, German Fed. Rep.
5.0	France, Sweden, Australia
10.0	Italy
(data not available)	Great Britain

Source: Adapted from Moy and Sorrentino, (1977, p. 17).

These ratios indicate that American youth unemployment may be less a special youth problem and more part of the general employment problem, than is the case in some industrial countries.

3.1.5 Factors Distorting Measurements of U.S. Unemployment

The notable decline in male labor force participation can be accounted for largely by the prolonged schooling of those under 25 and the early retirement of those over 54. Nonetheless, labor force participation rates (LFPR) are declining for men between 25 and 54 as well. Deutermann attributes 10% of the decline in LFPR for males of age 25-34 years, and 42% of the decline in LFPR for males of age 45-54 years, to liberalized disability benefits. Additional reasons include claims of ill-health or disability, some

increase in school attendance, and the rising employment of women. (Deutermann, 1977). Deutermann reports a major increase in disability claims. "Largely because of changes in eligibility requirements and an increased awareness of the program, the number of new disability benefits awarded each year increased from 250,000 in 1965 to nearly 600,000 in 1975." (Deutermann, 1977, p. 12).

In addition to disability benefits discouraging participation, other benefit programs contribute to unemployment. One of the major conclusions of a review of 34 studies of labor force trends is that benefits have a negative influence on working (Devens, 1977). Freedman notes the evidence that unemployment benefits add to seasonal and casual employment and may discourage the acceptance of low-wage jobs. (Freedman, 1978). Economist Martin Feldstein has studied this hypothesis in some depth and concluded that Unemployment Compensation in the U.S. has two distinct but related bad incentives. First, it reduces the cost of unemployment to those unemployed, thereby increasing the period of unemployment. Second, for all types of seasonal, cyclical, and casual work, "it raises the net wage to the employee relative to the cost to the employer," thus encouraging employers to organize work on a seasonal, cyclical, or casual basis and making seasonal, cyclical, and casual jobs too common. Feldstein argues that current Unemployment Compensation benefits have not been adjusted for the higher marginal tax rates which even low-wage workers now experience due to FICA income taxes. Feldstein concludes that for such a worker, unemployment benefits come close to replacing lost wages:

> The majority of unemployment recipients collect benefits that are at least 50 percent of their previous gross wage. These benefits are not taxed, so a 30 percent marginal tax rate on earnings (or a 70 percent net income) implies that the ratio of benefits to net earnings is five-sevenths, or that benefits replace more than 70 percent of the net wage. (Feldstein, 1976).

Adding the costs of employment, such as commuting, makes the net earnings replacement even more complete. Additionally, Feldstein argues, the low maximum tax and high minimum tax on employers amounts to a favoring of firms with high layoff rates. (Feldstein, 1976). All in all, then, it is clear that the unemployment rate is exaggerated by the incentives established in the Unemployment Compensation program. Other benefits programs such as food stamps also constribute error in the same direction but smaller degree. (Cain, 1979).

3.1.6 Older Workers and Retirement

The older worker in the U.S. appears to suffer less of a disadvantage relative to workers age 25-54, than do older workers in other industrial societies (See Table 5-5).

TABLE 5-5
Ratio of Unemployment Rates for Workers Age 55-64 to the Unemployment Rates for Workers Age 25 - 54 Nine Industrial Countries, 1974 (approximate figures)

Country	Ratio of UR (55-64) to UR (25-54) (for 1974)
Italy	.33
Australia	.5
U.S.A.	1.0
Canada.	1.3
France	1.3
Japan	1.5
Sweden	1.5
German Fed. Rep.	1.6

Source: Adapted from Moy and Sorrentino, (1977, p. 17).

This low rate of unemployment for the older workers, compared to the age 25-54 worker, in the U.S. may result from the declining labor force participation rate for older workers which Rones shows in Table 5-6.

TABLE 5-6
Labor Force Participation Rates for Males age 60-64, 65 and Over United States, 1957 - 1977

Year	LFPR, Males 60-64	LFPR, Males 65 and over
1957	82.5%	37.5%
1962	80.2	30.3
1967	77.6	27.1
1972	72.5	24.4
1977	62.9	20.1

Source: Philip L. Rones, (1978, p. 4).

In the 20 years following 1957, the decline in LFPR for males age 60-64 was about 20% and the decline for males age 65 and over was 46%, continuing trends continuing back dating at least into the 19th century. (Viscusi 1979). The situation for female workers is quite different, with participation rates both substantially lower and more stable. Rones attributes the declining LFPR for older males to health problems and retirement benefits, particularly in combination. But he cites statistical evidence that health is over reported as a reason for retirement and argues that social norms encourage claiming health reasons for retirement. (Rones, 1978). Viscusi finds little reason to believe that the health of older Americans has deteriorated in the past decade or two (Viscusi, 1979). Rones notes the importance of pension coverage:

> "The most significant factor in this decline (in LFPR of males age 60 and over)
> is the growing financial ability of older men to retire early.

....

....the rate of earnings replacement (by Social Security) for men who retire at 65 after making the median wage rose from 29 percent in 1967 to 45 percent a decade later. (Rones, 1978).

For older men, then, a low unemployment rate may well be related to the incentives of retirement benefits; as these increase in adequacy, one may anticipate further increases in early retirement and, perhaps, increases in the reported incidence of retirement due to ill-health.

3.1.7. Employment: A Summary

These characteristics of employment, in the U.S. and in many other industrial countries, present a context in which the employment consequences of any technology such as personal computers must be considered. The declining labor force participation of older workers mitigates the concern for technological displacement of older workers, though it should not remove this concern. The growth of new technologies may provide opportunities for properly trained younger workers to compete in the labor market with less up-to-date workers, although it might be hypothesized that the institutions and social norms which heretofor have guided youth into stable employment no longer can be taken for granted. Although women are increasingly employed in the secondary sector, the growth of the tertiary sector and its traditional employment of large numbers of women should make those concerned with female employment particularly concerned with the projections of major labor force displacement in that sector by computers of all kinds. Nonetheless, the review to this point makes it clear that employment is affected by a number of long-developing trends in attitudes toward work, and by long-evolving governmental policies as the administrative (or welfare) state nears the completion of its historical agenda. These attitudes and policies may well be mutually supportive. While there may be danger of labor force displacement, there is also a danger that the opportunities presented by computers and microelectronics will be lost to other countries because of government policies and social trends that discourage the creation of employment opportunities and inhibit people from accepting useful work.

3.2. Aggregate Demand and Structural Theories of Unemployment

In spite of the variety of complications in determining the extent of unemployment, substantial theorizing about unemployment has proceeded apace. The ostensible goal of these theories has been the design of government policies to abate the incidence of unemployment. Currently these theories, though having led to numerous government initiatives, are in disarray. It is not clear that either aggregated demand, or structural, theories of unemployment offer useful guidelines for those concerned with the employment displacement consequences of new technologies. The reasons in each case are different, however. For aggregate demand theories, it is their failure. For structural theories, which lead to a much wider variety of initiatives, the defects are more complicated.

The aggregate demand theory of unemployment is summarized briefly by Morely and Broadfield:

Throughout the post-Second World War period, the primary technique

used by governments to achieve their major economic objectives ot growth, stability, and full employment has been control of the level of aggregate demand for goods and services. The policies which have been used in this operation include variations in the level of taxation, variations in the level of public expenditure and alterations in the cost or availability of credit for both consumption and investment purposes.

While judging these policies successful for a long time in balancing the "potentially conflicting objectives of rapid economic growth, price stability and full employment," they continue:

> But the growing size of cyclical fluctuations and the accelerating trend of inflation in the late 1960s and early 1970s have increasingly suggested that these policies can no longer be relied upon as primary means of successful economic management. (Morely and Broadfield, 1976).

Aggregate demand management is inherently unsuited to managing inflation. Cuts in aggregate demand raise unit costs; increases in aggregate demand create inflationary pressure in sectors which respond quickly to stimulation "long before pockets of unemployment elsewhere are eliminated." (Morely and Broadfield, 1976). Indirect employment creation takes some time to occur, may have long term unanticipated consequences, and "the scale and timing of...effects are difficult to predict." Since aggregate demand policies have not contained inflation, those with the ability to do so have bought their own inflation insurance - cost of living adjustments for union contracts, and producer contracts which build inflation into the price quotations.

Killingsworth, in his Presidential Address to the Industrial Relations Research Association, claims that while the structuralists lost the battles in the 1960s, by the 1970s they had won the war with the aggregate demand theorists. He contrasts the two schools in the following way: Aggregate demand theorists prefer to draw their conclusions and policy recommendations from models of a perfectly competitive labor market, and tend to be general economists without a detailed understanding of labor market data series, their meanings, and their weaknesses. Structuralists prefer to draw their conclusions from direct observation of the economy, are intimately familiar with the unreliability of labor market data, and recognize the imperfections of knowledge, mobility, and competition. (Killingsworth, 1979). He writes:

> Structural unemployment, to put the matter as briefly as possible, is joblessness, usually long term - which results from basic changes in the economic structure: new technology, the decline of some industries and the growth of new ones, geographic relocation of industries, permanent changes in consumer tastes, changes in labor force characteristics, and so on.

Structural employment programs are, for Killingsworth, programs like manpower training, worker mobility assistance, area redevelopment - programs that deal with specific structural causes amenable to government programs. But U.S. Secretary of Labor Ray Marshall in enumerating his own list of structuralist programs, includes programs which are redistributive in nature, or otherwise responsive to social rather than economic structure. Among the programs which Marshall advances as structuralist are geographical coordination of people and jobs, improvement of labor market information,

training, improvement of labor market through anti-discrimination efforts, coordination of immigration with labor market needs, outreach efforts to bring people into other programs, and public service employment. (Marshall, 1978).

Second, the structuralist banner can also be used to justify programs which become institutional subsidies, such as the CETA programs in local governments. To the extent that local governments use CETA "trainees" in a manner of fiscal substitution, no real structural problem is addressed. Given the employment and other benefits which are distributed directly through "structural" programs in a political system, it should not be surprising if some of these programs are not based on sound economic analyses of the labor market. A large number of structuralist programs have been found lacking. Warneke reviews the experience of U.S. programs which aim either to adapt labor <u>supply</u> by training, by upgrading the most disadvantaged groups, etc., or to change <u>demand</u> by programs which increase employment opportunities. She concludes her review by finding that the results of training programs are generally viewed as disappointing. The demand-adapting programs are also troubled: conflicted by whom to aid (long-term or temporarily unemployed), in need of better targeting, lacking in needed support services, inflationary during recovery but hard to terminate, and prone to substitution effects rather than real job creation. (Warneke, 1976).

If aggregate demand policies are no longer acceptable because of inflation, structuralist programs, though advantaged by their more limited impacts when they go awry, in the aggregate are too often ill-conceived and ineffective with respect to the kinds of problems (as given abovehe labor market. A large number of structuralist programs have been found lacking. Warneke reviews the experience of U.S. programs which aim either to adapt labor <u>supply</u> by training, by upgrading the most disadvantaged groups, etc., or to change <u>demand</u> by programs which increase employment opportunities. She concludes her review by finding that the results of training programs are generally viewed as disappointing. The demand-adapting programs are also troubled: conflicted by whom to aid (long-term or temporarily unemployed), in need of better targeting, lacking in needed support services, inflationary during recovery but hard to terminate, and prone to substitution effects rather than real job creation. (Warneke, 1976).

If aggregate demand policies are no longer acceptable because of inflation, structuralist programs, though advantaged by their more limited impacts when d structural changes in order not to require worker adaptation. In their thoroughly international analysis, Morely and Broadfield reveal that the U.S. is not alone in its theoretical confusion regarding structural programs. "Structuralism" too easily becomes a banner under which all manner of well-intended but anti-structuralist programs are advanced.

The structuralist confusion, and the aggregate demand inadequacy, leave policy makers in a dilemma, however. If the latter no longer works, and nobody understands the former, policy makers are left with the capacity only for symbolic gestures and redistributive efforts. Perhaps this is a consequence of forces affecting labor markets which are not incorporated in either theory: inflation, international competition, demographics, and immigration. Morely and Broadfield see the economy as divided increasingly into those with and those without job security. The clearer this division, the more inflationary the aggregate demand expansion necessary to overcome it; the more inflation is expected, the less likely aggregate demand expansion will be effective at all. (Morely and Broadfield, 1976). These same analysts view return on investment in the secondary sector of industrial economies as shrinking. Freedman acknowledges that the decline in birth rates will begin to affect employment in OECD countries in the mid-1980s. And, it must be remarked, between "guestworkers" in many OECD countries, and undocumented

aliens in the U.S., the evidence is clear that unemployment as economic necessity is accompanied by a vigorous dose of unemployment as a matter of taste or preference. Recognizing the need in many industrial countries for the importation of workers raises questions about the adequacy of aggregate demand deficiencies as an explanation of unemployment. Other evidence raises doubts about the adequacy of basic structuralist notions as ssed by available workers, or other mismatches, such as of location, occur.

2. Capital Deficient Unemployment - in which 1, 1977). From his study examining only the industrial aspect of structural change, using as his indicator of change the percentage share each of sixteen industries of total employment in the U.S., Great Britain, and the German Federal Republic during the the 1960s and the 1970s, Turvey summarizes this:

> Statistics for a number of countries fail to show that industrial structural change has been more rapid in recent years than it was in the 1960s. Hence one major cause of increasing structural unemployment was not operative. Comparable data on occupational structural change are not available.
>
> ....
>
> Indicators of structural unemployment show that it has fallen in the Federal Republic of Germany and has not risen in the United States, while an examination of the United Kingdom data suggests low or zero industrial structural unemployment in both 1966-68 and 1972-75. (Turvey, 1977)

3.3. Conclusion: Bad News and "Good"

One leaves a review of literature on the employment situation in industrial countries with both good news and bad. The good news is that the situation in the U.S. is probably not as deviant (to the invidious side) as sometimes concluded from a mere examination of the official unemployment rates. Most industrial countries have suffered increasing unemployment rates in recent years, have youth employment problems, see their older workers dropping out of the labor force due to improved income replacements, offer various benefits which lead to an exaggeration of reported unemployment, experience rising female labor force participation, face growing competition for labor-intensive manufacturing from developing countries, and have various government programs and labor-management agreements which inhibit the creation of new jobs. The bad news is that existing theories offer little guidance for U.S. policy makers: aggregate demand theories because of their inability to cope with inflation, and structural theories because of the difficulty of applying them faithfully in environment rich in politics and poor in detailed understanding. And, it is not clear that the problem formulations implied in either set of theories really matches the problems currently being experienced in the U.S. or other industrial societies.

4. Projections of Employment Losses Due to Personal Computers

The most prominent concern with the employment consequences of personal computers involves net employment levels: will personal computers destroy jobs. This review concludes that, in the U.S., the hypothesis of significant job loss due to personal computers is "not proven." In specific industrial sectors, the effects of computerization and/or microelectronics are

already evident. Concern for lost jobs must be balanced against a concern for productivity improvement however. Since no serious evidence of massive job displacement has been found, and, from the previous section, government policies to deal with major unemployment are not very reliable, there seems to be no need to jump in with action recommendations.

Europeans, particularly, have been alert to the employment losses which might be attendent upon the widespread diffusion of microelectronics, of which personal computers might be seen as one manifestation. The European Trade Union Institute; a British union, the Association of Scientific, Technological and Managerial Staffs; and a special report to the president of France each contain estimates of job loss associated with microelectronics. No comparable studies have been performed in the U.S. In this section, these figures will be reviewed and compared with other relevant, though scattered, estimates and reports. But first, a few methodological comments need to be made.

Determining the net employment consequences of computers or microprocessors - or of any similarly pervasive technology - is not easy. One hardly can imagine the uses to which new technology can be put. The net employment impacts of a specific application might be calculated with comparative ease, but the net employment consequences of an idea not yet conceived cannot be. Personal computers - or the broader microelectronics - are in their range of imaginable impacts analogous to the electric motor or molecular biology. (Jenkins and Sherman, 1978). They create numerous opportunities for new products, services, even styles of living. Forecasts of job loss involve only one side of the coin; the other side includes both job creation in the computer industry and job creation for new products and services deriving from the computers. Rarely are the opportunities as well as the threats considered.

No revealed methodology underlies most of the estimates of job loss about to be presented. Jenkins and Sherman acknowledge the roughness of their figures, and call them "guidelines" rather than "estimates." Evans appears to derive his estimates by projecting from existing anecdotal sources. Nora and Minc acknowledge that their estimates come from "single studies of large enterprises in the tertiary sector, but their cooperation was so active that only aggregate results on productivity and employment will be published." (Nora and Minc, 1980). Officials of several large American corporations responded to our own brief questionnaire. (Appendix B.) To the best of our knowledge, none of the estimates of employment losses associated with microelectronics has used empirically-tested economic models. At best, then, these estimates should be treated as one-sided, almost worst-case scenarios of doubtful validity. Nonetheless, to the extent that they converge regarding the locus and magnitude of job loss, they invite being taken seriously. It should be kept in mind, regardless, that new job creation, either within or deriving from microelectronics, remains largely outside this analysis.

4.1. The Estimates in Summary Form

In general personal computers and microelectronics are seen as likely to cause substantial job loss in the financial services industry, banking and insurance. Over the next 25 years, Jenkins and Sherman see employment in these industries in the UK as declining by 50%. Nora and Minc see 30% shortfalls from otherwise expected employment in these industries in France in only ten years. Evans cites various industry or corporate studies and reports that offer similarly drastic figures. Some American respondents offer similar estimates, but others do not. Outside of these office industries the forecasts are more mixed. Jenkins and Sherman see drastic job loss just about

everywhere; Evans' estimates become more selective and anecdotal; Nora and Minc see drastic changes in the jobs of secretaries but do not estimate net job losses, and see possible disruption in social insurance and postal services but estimate neither the magnitude nor the timing in their summary report. Numerous reports of job losss in specific industries, such as printing or telephones, are available. But it remains unclear whether these estimates reflect more than the common fluctuations in employment within industries that are consequent upon changes in consumer demand, foreign competition, new product development, industry life-cycle, or, even technological change, computer-related or otherwise. The available models of the employment consequences of large computers, find employment losses of almost negligible proportions. These aggregate and industry-specific estimates of job loss from computers and microelectronics do not compel public action, once the estimates are critically examined. Rather, since the worst-case scenarios, however unconvincing, do involve serious disruption, contingency explorations and careful monitoring might be initiated now, "just in case."

4.2. "The Collapse of Work:" A Pessimistic Scenario

The most daring and comprehensive set of estimates is provided by Jenkins and Sherman, the General Secretary and Director of Research, respectively, of the Association of Scientific, Managerial and Technical Staffs (ASMTS), a sizable British trade union of white-collar employees. They see job loss from microelectronics in just about every industry, and daringly project out as far as 25 years. They concede that the net impact of large computers was "positive in terms of jobs." (Jenkins and Sherman, 1978). Microelectronics, they warn, is different.

Managers will not overstaff around microelectronics, for they have advanced on the learning curve; the new computers and microprocessors do not have the same high labor requirements for production, use, and maintenance as the older and larger computers; and many of the labor-intensive systems required in the use of microelectronics are already in place. The following Table (5-7) summarizes their estimates by industry of the expected job loss. These estimates reflect more than microelectronics. The creation of new jobs is acknowledged, though not really discussed. Other technologies and economic forces receive attention along the way to the presentation of these "guidelines," although microelectronics is seen as the most significant effect. Trends affecting all the industrial countries are recognized and discussed. Therefore, attribution of the projected job losses to microelectronics alone would be misrepresentation of the work of Jenkins and Sherman. The basis for these estimates is not given. Apparently, however, their analysis involved projecting effects on occupations through to industries, with occupations classified according to varying degrees of vulnerability to microelectronic technology. The work force is presumed to be about a constant 20 million.

This portrait of almost unrelieved grimness contains some notable projections. Almost one million jobs are lost in the distributive trades, with supermarkets and cost-conscious shoppers sharing the burden with microelectronics for the loss. 500,000 jobs are seen to be lost in "insurance, banking, and finance," and another 400,000 are to be lost in "transport and communications." "Vehicles," "electrical engineering," "mechanical engineering," and "textiles" are each foreseen as losing at least 300,000 jobs during the next 25 years, with "textiles" losing three-quarters of its work force in that time. Twenty-four of the twenty-seven industries are foreseen to lose jobs, with the average percentage loss being 33%

"GUIDELINES"

INDUSTRY	Employment, March 1978 (000)	Employment, Short Term (up to 1983) (000)	Employment, Medium Term (up to 1993) (000)	Employment, Long Term (up to 2003) (000)	Percent change, 1978-2003
Agriculture, Forestry and Fishing	357.3	340	300	300	- 16%
Mining & Quarrying	341.7	310	280	250	- 27
Food, Drink and Tobacco	688.7	630	500	450	- 35
Coal & Petroleum Products	36.9	35	30	25	- 32
Chemical & Allied	428.6	430	390	360	- 16
Metal Manufacture	469.7	450	350	250	- 47
Mechanical Eng.	928.1	920	800	620	- 33
Instrument Eng.	148.3	130	100	80	- 46
Electrical Eng.	741.4	700	520	410	- 47
Ship building & Marine	174.1	170	120	80	- 54
Vehicles	786.6	750	500	400	- 49
Metal Goods	535.5	540	500	430	- 20
Textiles	468.3	430	300	120	- 74
Leather & Fur	40.4	40	38	35	- 13
Clothing & Footwear	365.3	350	260	220	- 40
Bricks, Pottery, Glass & Cement	261.3	260	240	190	- 27
Timber & Furniture	258.7	255	250	220	- 15
Paper, Printing & Publishing	536.2	500	350	250	- 53
Other Manufacturing	325.5	310	300	400	+ 23
Construction	1215.5	1200	1000	1000	- 18
Gas, Electricity & Water	339.1	340	350	350	+ 3
Transport & Communications	1413.8	1300	1000	1000	- 29
Distributive Trades	2657.1	2550	2000	1600	- 40
Insurance, Banking & Finance	1136.6	1050	780	650	- 43
Professional & Scientific	3589.3	3650	3500	3650	+ 2
Public Admin.	1872.1	1600	1700	1800	- 4
Misc. Services	2249	2100	2100	2000	- 11
TOTALS	22,365.1	21,340	18,558	17,140	- 23

Source: Clive Jenkins and Barrie Sherman, The Collapse of Work (London: Eyre Methuen, 1979), adapted from pp. 116-123.

TABLE 5-7

(standard deviation - 17%). Only "other manufacturing," "gas, electricity and water," and "professional and scientific" are projected to gain employment. Overall, 5% of the 22,365,100 jobs are seen as lost by 1983; 17% are lost by 1993; and the loss between 1978 and 2003 is approximately 23%. Even "public administration" is seen as losing employment, with a notable drop in employment of almost 15% occurring by 1983, with slow growth of six-tenths of one percent per year for the next 20 years.

While one might construct a number of scenarios of the sort provided by Jenkins and Sherman, none would be either more or less plausible than theirs without a great deal more information about the analytics and assumptions than Jenkins and Sherman provide. The personal computer is one part of this revolution, though its share of the whole cannot be well-specified without extended and probably arbitrary definition.

Some problems with their scenario can be noted. Jenkins/and Sherman have been strong advocates of the development of a British microelectronics industry. However, their projections do not appear to presume that such an industry will be developed in the UK. In a society literally saturated with microprocessor technology, numerous new jobs in manufacturing, sales, service, hardware and software engineering, programming, applications engineering, and telecommunications could be expected to develop. Related to this concern, given that they project forward for 25 years, the possibility of entirely new industries arising ought not to be ignored. Third, the modest gains in "professional and scientific" employment, and the projected decline in "public administration," suggest that Jenkins and Sherman have constructed a worst case scenario, perhaps to stimulate debate. If one accepts the proposition of Wenk, that governments exist to prevent calamitous futures (Wenk, 1979), then Jenkins and Sherman provide an important stimulus to more rigorous analysis and contingency planning, even if the specifics of their projections seem at times excessive.

4.3 Projecting from Observed Experiences: The ETUI Report

Evans has prepared a less well organized set of estimates for the European Trade Union Institute (ETUI). The "central concern" of his report is that "....the impact of microelectronics on manufacturing and tertiary sector employment in Western Europe is taking place at a time of already severe conjunctural problems of both structural and demand deficient unemployment in Western Europe which are likely to persist on unchanged policies into the 1980s." (Evans, op. cit., p. 106).

Like Jenkins and Sherman, he acknowledges that past computerization has not had significant negative effects on employment in the tertiary sector but asserts structural effects - specifically, a shortage of computer staff at a time of generally high unemployment. He also states that it is hard to calculate the full effects of technological displacement on workers: cheaper products may have greater sales; savings may (or may not) promote employment-producing investment; cheap products (e.g, electronic calculators) may replace existing, more labor intensive, alternatives; wages may rise for workers remaining after the technological change is adopted. (Evans, 1979). Recognizing that "giving categorical quantitative employment forecasts for employment is fraught with difficulties,"Evans chooses to project from cases where the technology has already been introduced. Such a strategy emphasizes scattered reports of likely the most successful applications and/or those with the most obviously negative impacts on employment. Further, primary job loss is likely to be emphasized, and secondary job creation likely to be overlooked.

Evans' projection of substantial job losses derived from anecdotal

evidence summarized below by industrial category. Unfortunately, his examples are completely anecdotal: there is no standardization of dates, measures, or subjects.

Replacements of Electromechanical Machines. Electronic job losses of 50% to 90% in plants manufacturing cash registers in the 1970's. Decreases in employment for related products of 10% to 35% in the 1970's.

Telephone Exchanges and Telex Machines. Manufacturing employment declines of one-third, with substantial increases in output reported in several European countries. Projections of even larger job losses common. Telephone operator, installer, and maintenance employment is seen subjected to similar shrinkage.

Clocks and Watches. By the mid-1970s the Swiss watch and clock industry had lost 46,000 jobs, and the German watch industry had lost 40% of its employment.

Printing Industry. Twenty percent declines in employment during the 1970's in UK and DFR due to computerized typesetting among other factors.

Office Employment. Discussion here emphasizes relaxed growth rates for office employment, and projections of possible but yet to be realized job savings through automation.

Distribution. "Significant falls in employment in distribution have taken place in a number of Western European countries, part of which can be seen to be due to the introduction of new technology." There may be errors in the figures given, however; Italy is shown as losing 12.5% of its jobs in this sector in one year.

Other Industries. Remaining numerical reports involve isolated examples in auto, television, taxi meter and sewing machine assembly.

In summary, several industries seem particularly vulnerable. Electromechanical machines are being replaced by electronic ones with much lower labor requirements for assembly and maintenance; shift of parts production backwards to electronics firms does not recoup the lost jobs. Telephone exchange manufacturing, maintenance, and operation all involve the same employment threats as other electronic-for-electromechanical substitutions (e.g, adding machines, etc). Clocks and watches may already have experienced their employment revolution.
Automotive assembly offers some possibilities for the replacement of assembly workers by robots; however, this is a line of work often criticized as being inhumane. The printing industry continues to be volatile due to new technology; the technology currently being replaced was itself at one time a threat to employment in this industry. Office employment in financial services, but also in government and industry in general, is seen as threatened. Employment reductions are but rarely reported however. Evans' list of affected industries is substantially shorter, and the losses less dramatic, than the comparable offerings of Jenkins and Sherman.

The recounted experiences, however espisodic they appear when taken in the aggregate, do suggest the existence of severe disruption in specific industries. Some cautions need to be advanced however. Evans notes that "technologies, such as numerically controlled machine tools or robotics, have existed for a number of years without the rapid uptake that was predicted in

Western Europe." While threats of employment losses in office work are common, with word processors presented as particularly ominous, shortages of typists (at prevailing wages) have been recurring problems in many American cities. The literature begins to get circular after a very short time: the citations begin to repeat. Many of them appear to be based on opinion rather than hard analysis. Almost all offer opinions only on primary job losses without equal consideration of secondary job gains.

4.4. The Nora Report

At the request of the President of France, Simon Nora, Inspector-General of the Ministry of Finance, prepared an assessment of the implications of telecommunications development for France. His report, prepared with Alain Minc, has a summary volume which was recently (April, 1980) published in English by the Massachusetts Institute of Technology Press. Twelve appendices (in three volumes) prepared by the staff of a Commission on the Computerization of Society in the Ministry of Industry with advice, review, and counsel from other government authorities, and agencies, and from private individuals and companies, have not been published in English; and ten "supporting documents" prepared under similar auspices. The Summary Report offers some gross projections of employment loss in office industries, based on consultations with several large enterprises. One appendix develops sociopolitical approaches to analyzing the effects of computerization, and another presents macroeconomic models relevant to the employment;productivity: foreign trade dilemma. Employment projections appear guided by surveys rather than economic models. For the most part, this report, which has received substantial attention in the press, is concerned with the distribution of power and conflict within France, and with the independence of France within the community of nations. Employment and working conditions are a subordinate concern.

Nora and Minc assert the close interdependence of employment and foreign trade: computerization will either "worsen or help solve the structural problems of the crisis of French society." If computerization decreases employment without "helping to reestablish the foreign balance," the problems will worsen. If "by lifting the trade imbalance it gives economic policy the freedom it needs to foster new growth," then it helps solve the problems. In general, they conclude, on the basis of "surveys in key sectors" that "under the influence of telematics and automation the service industries will release personnel, while the large industrial enterprises will expand with a constant level of employment." In the past in France, service industries have absorbed the increasing labor force arising from growing labor force participation rates, but this "adjustment mechanism" has already begun to break down. France, like many industrial societies, has had its balance of trade adversely affected by the rise in oil prices. This leads to a need to expand foreign trade through improved competitiveness and productivity, while productitity increases lead to employment reduction. Nora and Minc find that world markets cannot absorb the amount of French production that would be necessary to preserve current unemployment rates under requisite productivity levels.

In French industry, Nora and Minc see new growth possible only in small and medium size firms. Large firms in established industries face a need to improve productivity to meet foreign competition. Some traditional industries - they mention iron metallurgy and shipbuilding - are already behind. More competitive industries such as automobiles are fast losing position to their Japanese counterparts. The development of small computers for production management applications, and small computers "tough enough to

be installed in the work place" will lead to decentralization and to output increases at level employment.

Likewise, regarding the service sector, Nora and Minc entitle their discussion "No More New Jobs in the Service Sector." They examine five industries. In banks, they foresee not the 30% reduction in personnel which has been quoted, but a 30% reduction in number of jobs necessary to service the demand of 10 years from 1978, compared with the number which would be required were banking technology to stand still. Further, they note, there is no assurance that this potential labor saving can be achieved, as such a saving "would run up against structural red tape, individual resistance, and pressure from the unions." Similar savings are possible in the insurance industry over the next ten years, presumably on the same basis: - the 30% is measured in terms of the labor force which would be required, save for automation, to service the demand of a decade hence. Yet, Nora and Minc note that some companies have established a moratorium on the installation of new computer systems due to anticipated employee resistance!

Nevertheless, in both insurance and banking, they believe that automation must proceed in order to meet competition from aggressive domestic financial services firms, foreign banks, and insurance operations on an EEC-wide basis.

In social security, no external competitive pressure motivates automation, so Nora and Minc argue that a need to reduce costs will ultimately produce automation but hazard no guesses as to the time frame. Postal Service employment depends too much on "the rate of telecopier installations, the quality of postal services, and the service's internal labor problems for an accurate prediction to be made." Productivity gains from automation are less a threat than electronic mail and message services and the home publication of newspapers. Low investment requirements and the institutional dispersal and isolation of secretaries will further the automation of secretarial jobs, of which there are currently 800,000 in France. Data processing networks, telecopying, and typewriters with microprocesors will drastically alter the work of secretaries; the job will become one of supervising rather than performing tasks. Nora and Minc expect massive effects on secretarial employment, but say statistical evaluation of these effects are currently impossible.

The 30% job loss figure in banks and insurance has been widely cited for understandable reasons, even if the citation is usually without the very important qualification Nora and Minc offer, and which the reader is urged to note again: it is 30% of the labor force necessary to handle the workload a decade hence were computerization not to proceed, and that hypothetical figure only if computerization is unimpeded and used to its full potential. The actual figure, accordingly, is likely to be smaller by a substantial margin. The projection is of concern because growth in tertiary employment has been relied upon in France to absorb increases in the labor force participation rate. Nora and Minc do not claim that there will be a reduction in either tertiary or in banking/insurance employment from that which prevailed in 1978 upon the publication of their report.

4.5 American Trade Publication Reports and Other Studies

Most studies and reports in American trade publications do not offer specific figures for job displacement. The trade publications are perhaps understandably reluctant to offer such estimates for public and employee perusal. Additionally, the fear of widespread unemployment caused by microelectronics is not strong in the U.S. A.L. Robinson has assessed the matter in his contribution to a special issue of the prestigious journal,

Science, devoted to the effects of microelectronics.

> If the question asked is 'What impact will advances in electronics have on structural unemployment,' the answer is 'very little' according to most government economists and industry executives. (Robinson, 1977)

Where displacement has been observed, it has generally been handled by attrition or retraining, rather than by termination. Among the possible areas of severe impact, Robinson singles out retail sales and the U.S. Postal Service, with the latter vulnerable to electronic message transmission.

4.5.1 The Automobile Industry

In the automobile industry, a study prepared by the Monthly Labor Review recognizes many areas of application for microelecronics, but does not foresee significant displacement problems. Retraining of displaced workers is easy, and is encouraged by labor agreements. Computers will affect design as well as production jobs. (Critchlow, 1977).

At present, job loss due to computerization would probably not be at the top of anyone's concerns regarding the U.S. automobile manufacturing industry. As this industry shapes out over the next decade from the increase in energy prices and anti-pollution requirements, the employment consequences of computerization might become more salient.

4.5.2. Telephone and Communications Industry

Telephone exchanges were singled out by Evans and by Robinson as a product greatly affected by computerization. Michael D. Dymmel examines this industry and finds that in the future, demand increases will no longer offset productivity gains, so that in the 1980's employment will decline in the telecommunications equipment industry. His analysis reveals that these employment changes are the result of a number of technological changes, of which computerization is a major but not encompassing manifestation.

Employment in this industry, which Dymmel considers to be the 1600 operating telephone companies (The Bell System has over 80% of the 155 million phones in operation), peaked in 1957 and declined 11% by 1963 because of the diffusion of direct dialing as well as the introduction of data processing. Labor-intensive installation and central office functions grew throughout the rest of the 1960's in response to service demand growth. In the first half of the 1970's employment declined slightly due to electronic switching systems (ESS) and higher capacity cables as well as a tight economy. In 1977, employment rose again slightly. (Dymmel, 1979, p. 17). This discussion draws liberally from Dymmel's analysis, which will therefore not be specifically referred except when quoting directly).

Electronic switching, introduced first in 1965 (before the invention of the microprocessor), had reached 20% of all phones by 1976, and is projected to reach all phones by 2000. ESS was adapted to long distance in 1976 and is programmed specifically for the office in which it is installed, thus requires less skill in installation. Once installed, it monitors its own performance, diagnoses its own circuitry problems, and links with other ESS's to control centers for remote monitoring and maintenance. This self-maintenance capability along with generally higher reliability compared with electromechanical systems means reduced maintenance labor as well as reduced installation labor requirements. At the same time, capacity is increased by ESS.

In addition, computerization is affecting "almost every phase of telecommunications."

Computer systems having employment level or skills level consequences test trunklines by analyzing signal loss and noise; test crossbar switching networks to find and analyze limits to switching capacity; designate wiring assignments on main distributing frames in a way that improves load balancing and reduces wiring congestion; replace test-desk operators who locate customer-reported problems; automate switching and billing for operator-assisted calls; act as intercept operators for discontinued numbers replaced.

Dymmel sees no limits to the applications of computers in communications, and expects computers and communications to merge ultimately and produce "yet unimagined services."

Overall, Dymmel projects continued growth in the crafts, due to system growth, but the craft employment will grow very much more slowly than in the past as computers assume maintenance and testing tasks, and do-it-yourself installation grows in favor. Women, slipping from 57 to 40% of telephone employment between 1960 and 1977, will probably stabilize their percentage of this labor force at around 50%, as they penetrate the crafts in increasing number and as the operator labor force stabilizes. Finally, the industry will experience an increase in its proportion of sales and managerial employees as it seeks to assure the demand growth in its newly competitive environment. Dymmel concludes that in spite of its technological advances (or perhaps because of them?) "the industry is changing from a technology-based organization to one of greater market orientation." (Dymmel 1979, p. 16).

Concern with employment losses in this industry must be moderated by the fact that only this industry has shown faster productivity growth from 1967 - 1978 than it showed in the 1948 - 1967 period of generally rapid productivity growth. This industry, in fact, increased its productivity at a rate twice that of any of the other 10 industrial groupings during 1967 - 1978. (Bennett, 1979; Brookings Institution, 1979).

4.5.3. Insurance

Although applications of computers in these financial services fields are potentially numerous, reports of job displacement are rather rare. Most discussion of this industry will be included in a following section on "Applications." The potential is certainly impressive. Here is a report of one study by a well-known market research firm:

> A recent study of the insurance industry by Frost & Sullivan, Inc., an independent marketing research organization, reports that at best current computer applications represent automation of the basic (insurance) business.
>
> The gains still to be made have great potential significance, since only the financial services industries have the potential of automating virtually every internal operation — and this is particularly true of insurance. (Fischer, July 1975).

However, this same author, at the time the industry director for insurance of the IBM Data Processing Division, also reports this about the insurance industry: "Among the goals most frequently stated to me by insurance executives is the achievement of premium growth with level employment. Several large companies already have policies in place to bring this about." (Fischer, 1975).

Insurance agencies, as opposed to firms, offer isolated reports of labor savings from the use of minicomputers and mainframes. A Los Angeles agency reports doubling premium income with constant staff. Its two programmers have developed 72 programs in two years for accounting and operating (Hall, 1974). A South Carolina agency has doubled policy entry productivity, brought employee productivity to three times industry norms (in terms of gross premium volume), and decreased claims department employment. ("Big Payoff," 1976).

To the extent that automation reduces clerical errors, substantial changes in supervisory jobs could result, argues William Exton, Jr. The implication is that much of clerical and supervisory time is devoted to correcting errors; computerization could have a substantial impact were it to cut the error rate in half or make error correction substantially easier. (Exton, 1977).

Industry operational characteristics and market contingencies can affect the employment consequences of computerization. The Nora report claims that foreign and domestic competition enforces efficiency considerations upon financial services firms, but some empirical studies have concluded that cost comparison is not a leading factor in personal life insurance purchases, nor is it a major consumer demand. There is an adage in the life insurance business which is evident in the advertisements in Best's Review, that life insurance companies compete for agents, not customers. Employment savings in the life insurance industry may be redeployed toward better service rather than captured through attrition or layoffs. This view of the insurance industry is consistent with the industry's view of itself, (Beutel and Nuckols, 1978), but could be tested empirically by someone interested in formally modeling the impact of computerization on the life insurance industry.

4.5.4. Banking

Within the banking industry, like the insurance industry, few firm reports or estimates of job displacement are available. Office automation at New York's Citibank has received the most attention. At a convention several years ago of the Office and Professional Employees International Union, the most successful of seven unions interested in organizing banks, new organizing efforts were announced.

This union projected a reduction in the present one million lower level bank employees to between 500,000 and 600,000 eventually. (Banking, Vol. 66, 1977). The possible applications of automation in banking certainly are numerous. A Baltimore Bank reports that computerization enables 2.5 people to handle 40,000 personal accounts, while in the early 1970's nine people serviced 17,000. This saving derives in part from the use of bulk filing by statement cycle. (ABA Banking Journal, May 1979). The industry even has non-information processing activities that can be improved, such as coin handling. (Banking, May 1978). At Citibank headquarters in 1976 two minicomputers were regulating message routing, storage, and retrieval from around the world. This application cut its workforce for this function from 130 to 300 persons, with faster service and cost savings. (Asher, 1976).

The union convention referred to above claimed that Citibank's automation activities had led to a loss of 4,000 jobs. Other banks were purported to be imitating Citibank's automation by closing branches(!). The savings to Citicorp were, by 1977 were reported by Dun's Review to be $80 million after tax "if operating expense had continued to grow at the rate they had during the 1960's." Labor savings in the same article are set at 5,500

jobs, and reported as handled through normal attrition. (Dun's Review, 1977).

Further favorable reports on the Citicorp experience are not in evidence nor are similar reports on other banks, suggesting caution in accepting the initial evaluation of Citicorp's automation. The point to keep in mind is that the reported successful experiences are few in number even in banking and insurance. This may mean that they really are scarce, but it may mean that these applications are viewed in the industry as "nothing special." Rather, these industries may experience continual technology-related and other changes involving new services, expanded services, and efficiency improvements, all together in a seamless web. Computer-related job displacement may not be a phenomenal category of much interest to most people in the business.

4.6. A Short Survey of Some Financial Services and Other Companies

As part of this research, a short questionnaire was sent to a number of American companies (See Appendix B). The responses of 19 companies, most quite large and widely recognized, are mixed, but on the balance, mildly optimistic regarding the employment consequences of automation. The survey was sent to a sample of 100 large manufacturing, financial services, and other firms chosen for their prominence. Twenty-nine responses were received but only 19 of these provided usable data. Ten of the 19 firms providing usable data are from the "FIRE" (finance, insurance, and real estate) sector. Six of the rest are industrial corporations, two are service companies, and one is not known. The remaining responses indicate important reasons for non-responses. The vast majority of the 19 firms providing usable data expect employment in their firm to increase between 1980 and 1990. Of those making projections for their industry, most see industry employment growing as well. Almost all see radical increases in the proportion of their employees (or of employees in their industry — the responses are mixed as to referent population) using computers over the next ten years; several firms expect 100% utilization in one or another occupational class. Where displacement is expected, most respondents believe that it should and will be handled by attrition, with a minority favoring retraining and replacement by the firm. Termination is recommended only selectively.

Only a few respondents foresee sizable changes in level of employment due either to automation in general or to the microcomputer; those who do foresee changes are more likely to project employment increases than decreases, with the decreases likely to occur among clerical, operative, and laborer categories, and the increases more widely dispersed among the eight basic BLS occupational categories. The overall picture is one of increasing demand for the higher-skilled categories, and mixed to slightly decreasing demand for the lower-skilled categories. However, the data are spotty and the sample quite limited, so any conclusions from this survey should be considered in terms of how they fit with other evidence and speculations presented in this report, rather than at all conclusive on their own.

The firms which responded without data suggest why the available evidence on the impact of computers and microelectronics on employment levels is so scanty. Two large manufacturing companies asserted that employment levels 10 years hence simply could not be accurately projected even in the gross categories which we provided (the eight basic BLS categories). Three companies claimed it would be far too much work to collect the data for such estimates given the diversity of their operations. Two others simply said that they did not have the information, and two others asserted that their operations were so decentralized that such information was impossible to collect at all. Finally, one financial services company responded that the

effort itself was of questionable value. (Some of the declining respondents offered more than one reason.) The problems of employment projections must surely be more difficult for smaller, less professionally-staffed enterprises.

Each of five major life insurance firms responding (no property/casualty firms replied) saw increasing employment in the "professional, technical, and kindred" classification. Most projected declines in clerical employment in their firm and, if answering this part, in the industry. The declines projected are modest in all cases (no more than 10% over 10 years and usually less). Often no impact at all is projected due to automation or to microcomputers for an occupational classification. Some responses suggest an expected expansion of employment of considerable magnitude, but this is a distinctly minority view. All respondents do expect the majority of professional, managerial, and clerical employees to be computer users by 1990, with the projected percentages often exceeding 75%. Overall sales, assets, and employment are expected to increase. Attrition and retraining are the favored strategies for dealing with displaced employees, with termination having no supporters among this group of respondents.

Among the five respondents in banking, real estate, and non-bank financial services, computers are seen as mixed in their effects on employment levels. As this group of firms is more diverse in its character, so its responses, are more dispersed compared with the relatively homogeneous life insurance respondents. But the gains projected as a consequence of automation and of microcomputers are generally larger than the losses, in percentage terms. Overall, these firms expect employment to rise in their firms, sometimes quite sharply (e.g. 100% by 1990), and in the industry. The three of the five respondents who projected computer utilization by occupational class all expected substantial increases, with the proportions usually at least doubling when possible.

Among the remaining firms, eight out of nine see rising employment in most occupational categories, and six out of nine see overall employment increases. The impact of automation and of microcomputers on employment levels is seen slightly more often as positive than as negative and in about the same magnitude in either direction. The increases in the proportion of employees using computers by 1990, compared with 1980, is not as dramatic as the increase projected for the FIRE industries. Attrition and retraining are the preferred strategies for dealing with displacement of employees. On the balance, the industrial and service corporation respondents see more displacement than the FIRE respondents. However, for no firm or industry is 10-year (by 1990) job loss projected at more than 15% in any occupational category. This mean loss for any occupational category for which a firm projects a loss is only 6%, due to microcomputers, and 11%, for automation in general. Respondents see no measurable impact of either automation or microcomputers on employment in an occupational classification in over half the possible cases.

The results of this very limited survey do not provide great cause for alarm regarding the employment consequences of microcomputers, or of automation in general. Perhaps only optimistic firms replied: this would be an understandable manifestation of response set. Also, in spite of a strong pledge of confidentiality (quite evidently upheld here), respondents expecting adverse consequence might have chosen not to reply due to their unwillingness to provoke employee anxiety should their projections reach their employees. However, even the life insurance companies, representing an industry widely thought to be extremely vulnerable to automation in general and microelectronics in particular, offer a generally optimistic forecast of employment consequences. A fortiori, then, this brief survey reinforces the conclusion that emerges from the rest of this analysis of employment

consequences: the incidence of primary job displacement will be substantially less than projected by the European trade unionists. Regarding jobs which might otherwise have been created but for automation or microcomputers, this limited survey provides little guidance, but the shadings are toward a moderate position on this issue too.

4.7. Studies of the Economy-Wide Impacts of Computers on Employment Levels

Studies of the economy-wide impact of computers on employment levels are restricted to large mainframes and are based on data usually at least several years old. The results are amazingly congruent: the impacts are slight, tending toward the negative. One percent is a familiar figure in such studies. Evans cites a study by the Swedish National Bureau of Statistics which estimates that between 1968 and 1977, "computerisation resulted in a manpower saving in the economy as a whole equivalent to approximately one per cent of the total labor force." (Evans,1979, 89). A British study released in December, 1978,is reported by the Economist:

> Mr. Callahan is to welcome at the NEDC (National Economic Development Council) meeting a paper by the industry department that is based on a study the Central Policy Review Staff (think tank) into the social and employment implications of microelectronics. Provided Britain can become competitive in putting this technology to work the government now officially reckons more jobs will be created than lost. (Economist, 1978 p. 111).

A 1965 British study involving 400 enterprises found little if any displacement due to the long lead times in installation of systems, and the labor savings already captured from the installation of punched-card equipment many years before. The author reporting this study asserts that the generally tight labor markets in industrial countries (compared to those of developing countries) makes displaced workers easy to absorb. (Baron, 1976).

Two studies more directly accessible reach similar conclusions: Porat's work on the "information economy" and Stoneman's study of Britain. Porat has used input-output analysis to study the "information economy" and produced a nine-volume report of his findings. This study directs itself to the question:

> What share of our national wealth originates with the production, processing and distribution of information goods and services? (Porat, 1977).

Particularly relevant for this report are two illustrative analyses performed by Porat. In one, Porat estimates the total effects of a $1 million computer sale. His matrices indicate that such a sale would involve direct effects of $588,000 in purchases from other industries and $412,000 in value added. The indirect effects total to $1.607 million, close to two-thirds of which are in the "office computing" classification. The total effect on industry output comes to about $2.2 million. In this illustration, Porat demonstrates the possibility of estimating the direct economic impacts of computer hardware purchases. (Porat, 1977, 75-78).

A second illustration is more germane to the employment question. Porat analyzes the consequences of doubling the national investment in information capital. Specifically, he asks:

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> Holding total investment constant, what is the impact on the economy of doubling investment expenditures (or gross capital information) in information capital goods?

His definition of information capital does include more than computers (e.g., printing presses and office buildings, as opposed to factories and trucks and machine tools). He reports that the net impact on the economy was a net loss of $2.4 billion in output and a net loss of 52,000 jobs. The major reason for job loss was that non-information industries have longer interindustry production chains than information industries. The direct effects on employment levels were positive, but the indirect effects turned the overall employment impact downward. Regarding new output, Porat notes that his analysis does not incorporate the possibility that the information investment could stimulate productivity. Therefore, the output loss may be overstated. This second illustration is important because it tests in a systematic, if indirect and suggestive, way the hypothesis that expanding computerization will have disastrous effects on the labor force. Porat finds that the employment effects would be modest. (Porat, 1977).

Several reservations must be made regarding this work. First, it is all based on data for the U.S. economy in 1967, and his work has not been updated with more recent data. Second, he deals with the "information economy," which includes close to half the GNP as measured by value added. This is a much broader notion than the computer economy.

Stoneman finds, through a systematic analysis involving "heroic assumptions," that the saturation of the British economy by third generation computers would have only a modest impact on the labor force. He describes his work in a summary article:

> In this paper we investigate the effects of computerisation on an economy on two levels. First we compare an economy with 100% computer penetration, with a non-computerised economy. This illustrates what effects can ultimately be expected. Secondly we analyze the changes along the transition path as the economy approaches 100% penetration, i.e. we illustrate what effects have been realised and what further changes can be expected prior to saturation. (Stoneman, 1975).

Stoneman estimates labor savings per third generation machine and offsets this with "net changes to labour requirements in capital goods construction." He estimates the satiation stock of third generation computers and then calculates the effects of this stock on labor demand. Finally he estimates the effects along the transition path.

Using British Government labor surveys, Stoneman estimates that the net job loss per third generation machine is 42-man years. He adjusts this for skills differences; for machines in scientific and other uses with minimal employment displacement impacts; for machine assembly, installation and economic life; and other factors. The adjustments yield a net loss figure of 21 man-years per year per machine. He then converts this to a number of machines. Stoneman estimates that, for the UK, satiation would be 10,142 third generation machines. For a 1970 level of output, this translates into a "net savings of 178,752 man years which represents 0.79% of the 1970 labor force," or, if 72% of the machines are home produced, the figure becomes 0.87% of the 1970 labor force. Estimating along the transition path to a future saturation condition, he sees a loss of 257,547 jobs in 1978 at 1978 levels of output, or 230,223 jobs if the UK. produced 100% instead of 72% of its own computers. This is approximately 1% of the labor force. In conclusion he

states that, "overall the effects of computers on labour demand appear to have been small and to be unlikely ever to be large." (All figures and quotations are taken from Stoneman, 1975, pp. 590-606).

Among the reservations which must be made about this study is that it is about third generation mainframes, after all, and not about microcomputers. As Jenkins and Sherman point out, there are reasons to believe that the smaller machines will occasion fewer new jobs in production, installation, and staffing. Further, Stoneman himself calls some of his assumptions "Heroic." In spite of these reservations, his overall results are in the range of other studies examined here. Although none of the studies individually are terribly persuasive, the homogeneity of results does tend to be convincing about the employment impacts of large mainframe: overall job losses are very small.

4.8. Semiconductor Manufacturing: An Example of an Information-Intensive Manufacturing Industry

The common preconception of an "information industry" is an industry such as banking, insurance, real estate, and the like. These are, of course industries which are highly information-intensive. However, it is important to note that some manufacturing industries, in particular some of our most innovative manufacturing industries, also have a relatively high proportion of information workers. In a review of the U.S. semiconductor industry, the Industry and Trade Administration of the U.S. Department of Commerce examined a variety of aspects of this new (it did not exist in 1948), highly innovative industry. Although the latest figures reported by the Department of Commerce study (Office Producer Goods, 1979) concerned the occupational distribution in 1971, there is no reason to believe that the proportion of information jobs in the semiconductor industry has diminished. More than likely, it has increased. In mid-1971, approximately 54% of occupations of the semiconductor industry could be classified as information jobs. About 9 percent of the jobs were held by skilled workers, of which we estimate one-third could be information workers, 36% were held by semi-skilled workers with only one or two percent going to unskilled labor. Thirty-four percent of the employees in the semiconductor industry are professional and technical workers.

Although these data are confined to the semiconductor industry, our experience leads us to believe that this distribution of employment is typical of technology-intensive industries in general. That is, the numerical majority of workers have information jobs. Furthermore, two of every five information workers are professionals in these industries.

Further evidence of this is given in the numbers for comparative labor intensiveness of the semiconductor manufacturing industry as compared with all U.S. manufacturing industries shown in Table 5-8. The ratio between payroll and value of output of the product in the semiconductor industry has consistently been about double that of all U.S. manufacturing over the decade between the mid-60's and the mid-70's.

If the semiconductor manufacturing industry can be considered a harbinger of future industrial development within the United States, it is clear that there must be a trend toward increasing demand for professional workers accompanied by a complementary decline in demand for unskilled labor. Our experience with other, more traditional, elements of the information industry in earlier research (specifically insurance companies), as well as the results of the survey reported in Section 4.6., show that this same trend exists as well although the proportion of professionals is not as pronounced.

4.9. Summary

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A number of studies on the employment consequences of computers have been reviewed. Several have projected major displacement and others have seen minor displacement at best. Overall, the conclusion must be that the latter are more likely on the mark, with the following reservation: that the more methodical the study, the more likely it is to be concerned with large mainframes. The projections of major job losses, such as by Jenkins and Sherman, are not supported by much in the way of evident method. Evans' report is full of isolated anecdotal materials and, in addition, these materials deal with quite a limited range of applications. The Nora report is widely misquoted regarding displacement in the financial services industries of banking and insurance. Its actual projections are much more circumscribed than the quoted 30% job loss in 10 years. The telephone and communications industry appears to be one that has had and will experience job losses in the near term. This is also the only major industrial sector showing accelerating productivity improvements in the U.S. Concern about its employment levels must be moderated by admiration for its efficiency. The insurance and banking industries offer opportunities for automation, but reports offering numerical estimates either of actual or projected job loss are hard to come by. Computerization appears to be but one of the many technological advances affecting these industries, the commitment of which to employment reduction is not clear. Responses of 19 firms to a short survey by this project indicate an expectation of only marginal job losses due to automation or, more specifically, to microcomputers. Most respondents expect overall firm and industry employment to increase. Ten of the 19 respondents were in the financial services industry, half of these in life insurance. Finally, the elaborate modeling efforts of Porat of the U.S. and Stoneman of the U.K. both find minimal job losses due to computerization.

Overall, the verdict on the charge that computers, microcomputers, or microelectronics will cause sizable job losses must be "not proven."

Such a conclusion should not lead further to one that no employment consequences will result. Specific industries may be impacted heavily in terms of employment levels. Shifts may well occur in demand for certain skills. New jobs, in such areas as programming and software engineering, will arise. Part-time and at-home work may be encouraged. But existing large institutions must cope with a host of complicating factors in introducing microcomputers into their work processes, including the problems attendent to reorganizing workflows and job assignments, interfacing this new technology with other ongoing changes, and tailoring applications for the specific requirements and contingencies of their business environment. The most radical projections — either of job loss or of beneficial impact — share an insensitivity to the arduous details of implementation. What is needed are studies of specific industries which are likely to experience substantial microcomputer impacts. Such studies would examine applications through field interviews covering the numerous implementation costs and contingencies in order to develop reasonable schedules for the implementation of plausible applications. Further, second order effects, e.g. of reduced costs on service demand, or of new economic activity enabled by quality improvements, should also be considered. Studies presently available and reviewed here are, for the most part, rooted in a past of questionable relevance, or project a future based on primitive or even clearly inadequate method.

5. Applications and Barriers To Them

The literature on employment losses does not fully reflect the potential applications of microcomputers. In this section, a wider range of application will be suggested in order to provide a better picture of the

potential employment effects of this technology. Again, however, it is hard to segregate microcomputer applications from applications of computers in general or of microelectronics. The discussion in this section will necessarily mingle these technologies.

Although the possible range of applications is quite large, the actual adoption and diffusion of microcomputers and correlative technologies faces a number of barriers which will moderate any employment consequences, whether detrimental or beneficial. These barriers include economics, slow personal adjustment to change, technical difficulties in application, and dependence upon or interdependence with other technologies. Among these other technologies is the social technology of work organization and management, which mediates between microcomputers and the loss of office employment.

In the first half of this section, applications in manufacturing service and office industries will be reviewed. In the second half of the section, barriers to applications will be discussed, though not in specific reference to the applications noted in the first part of the section.

The conclusion of this survey of applications and barriers to them is that the preceeding section's projections of minimal job displacement due to personal computers are strengthened. While applications are numerous, barriers to their institutional realization are many. The employment consequences of personal computers will reveal themselves in an evolutionary or incremental manner, allowing gradual, "trial and error" private responses by individuals and organizations. What interventions by government may be necessary are very specific and limited. This does not make them unimportant but does mean that these interventions are likely the proper province of specialized agencies for the most part rather than of general public debate.

5.1. Applications Possibilities

The wide range of possible applications of microcomputers and microelectronics may contribute to the large amount of attention these technologies receive from those concerned about employment. These applications, moreover, are likely to be new, rather than to involve the transfer of existing large computer applications to smaller machines. Evans concludes:

> It is unlikely that the development of the micro-computer. . .will significantly challenge the use of mainframes for established EDP purposes. Current restrictions on word length and speed of operation will outweigh the advantages of cost reduction. Moreover improvements in software, through, for example, more sophisticated database management, depend to some extent upon increasing computing power which micro-computers would not be able to provide. (Evans, 1979, p. 60).

He foresees continued demand for improved capability rather than for reduced price in "generalized EDP applications." (p.59). Rather, microcomputers and microelectronics will free organizations from dependence on large data processing departments by allowing a larger range of applications in more dispersed sites — such as within individual office machines, or regulating automotive engines. (p.5). With regard to manufacturing, improvements in control are particularly important.

Evans quotes Floyd Kramme of National Semiconductor, who asserts that "'Any product that uses springs, levers, stepping motors or gears is performing logic and that product should be build of semiconductors.'" (Evans, 1979 p. 42) With that view of control and logic functions, the range of microcomputer applications must surely be hard to enumerate.

Policy Analyses
Employment

As early as 1974 the financial press was predicting that microcomputers would invade home, factory, hospital, and store and auto. Among the applications predicted for "electronic wizardry" were home heating/cooling regulation; machine tools and process controls; eyeglass fittings, blood analysis, and prosthetic devices; point-of-sale and automatic teller machines, and auto carburetion and computerized traffic controls. This article noted that California had already ordered 162 computerized ramp-metering systems for its freeways. (Barron's, 3ff). Another early prognostication compared computers to the steam engine, arguing that the computer revolution had just begun. This article stressed robots ("programmable mechanical assemblers") and programming by untrained persons. (James, 1975, p.11). As the years have passed, many of these applications have occurred.

One broad ranging review of actual and possible applications is the report by Evans for the European Trade Union Institute, already referenced here. This report is particularly detailed regarding applications in secondary and primary industries, but will be supplemented by other sources particularly for tertiary industries. The following paragraphs provide a portrait of possibilities, but should not be read as providing a portrait of applications which are either widespread currently or likely to be widespread in the near future.

Automobiles. Evans sees microprocessors as having applications in fuel injection and carburation, headlight control, traction control, exhaust emission control, and "air cushion control." He also sees more complicated systemic controls in which many variables are sensed and, for example, optimum spark advance is calculated and effected. However, he also notes that the automobile is a strenuous environment for electronic components, so that applications will come slowly. (P.70). Graphic terminals are used by drafting technicians with the computer processesing the designs to operate automatic drafting machines and numerically-controlled machine tools. (Critchlow, 1977, p. 32-33). Other uses noted by Critchlow include inventory control, work scheduling, and production line balancing, though these types of applications have been studied for some time.

Robots are being used in the automobile industry for tasks like welding and paint spraying. As robots of improved capabilities become available, they may will also play a larger role in assembly operations. Evans suggests that robots may encourage "cellular manufacture" over assembly lines. (Evans, 1979 p. 52). Critchlow wrote three years ago from his vantage point at the U.S. Bureau of Labor Statistics that there was no data on the extent of use of computers in the production of automobiles. (1979, p. 33). Many recognized applications recognized the functioning of autos themselves (e.g., traction control devices) but not the major labor inputs. A Business Week survey notes that in the U.S. robots have been used to relieve auto workers of "hazardous, dirty, or monotonous" work, and quotes the "official robot watcher" of the United Auto Workers who comments, "I don't consider this a great threat to working people." (Business Week, 1980, p 63).

Continuous Process Industries — chemicals, glass, ceramics, petrochemicals, steel. Microelectronics have many possible applications in monitoring temperature, pressure, and composition of raw materials inputs. But applications are affected by the rate of obsolescence of existing plants and the very high cost of scrapping existing plant. (Evans, 1979, p. 490).

Batch Process and Mass Production Industries. Evans expects a basic application of microprocessors to be in hand-held electrical tools, improving

the performance of these implements. More significant for employment considerations, he notes that with computer-assisted design, the "highly skilled toolmaker's job" may be "completely eliminated," as computers permit direct production from engineering specifications. (Evans, 1979, p. 50) This seems a possible exaggeration of an impact already seen with numerically-controlled machine tools.

Mechanical Handling. Microelectronics have already begun to be incorporated into forklift trucks and conveyor controls. They may contribute to "integrated automatic warehouses and automated flow lines within factories." (Evans, 1979, p. 53). Applications are likely to grow "piecemeal" due to the sunk costs in existing plant and equipment. Nonetheless, as warehousing becomes more automated, some jobs will be affected adversely.

Telecommunications. This subject has already been explored at some length in an earlier section. The evidence is that microelectronics is one of the major factors leading to a decline in employment in telecommunications, particularly in the telephone companies, in that job losses may increase as electromechanical equipment is replaced by electronic equipment in many countries. The applications affect manufacturing employees but also installation, maintenance, and operations employees.

Printing and Publishing. Evans sees this entire industry transformed by computerized typesetting and photocomposition. Possible are a wide range of changes including the partial obsolescence of print media and their replacement by direct linkages to the consumer/reader. Editorial and delivery system occupations, as well as skilled trades, would be affected ultimately. However, whether there would be a net gain or loss is difficult to estimate without careful detailed analysis. (See Evans, 1979, pp. 53-54). George Washington University has just completed a technology assessment on this topic.

Other Process Applications. Evans lists medical diagnosis, teaching aids, computerized classification and reference systems for libraries, computerized railroad traffic control, ship navigational aids, and simplified maintenance requirements for appliances, motor vehicles, elevators and other electromechanical equipment for which electronic equipment can substitute, as areas of application for microelectronics. Some of these applications areas may significantly involve personal computers, particularly the first three in the list.

Travel Agencies. The increasing complexity of schedules, fares, and tours, as well as the convenience of booking travel, hotel, and automobile rental reservations on a single system make these computerized reservations systems almost indispensible for the modern travel agent. The commercially available systems are based on very large mainframes, and have taken well over a decade to develop and implement. (Business Week, April 7, 1980). Applications possibilities for personal computers occur within this already computerized environment, one which seems to grow in complexity to match the increased capabilities.

Pharmacies. As a consequence of insurance plan proliferation, state records keeping requirements, and generic substitution pressures, 2000 of the country's 50,000 drug stores have contracted for time sharing services, and all ten of the leading drug store chains have developed "ambitious" plans for

computerization in the next two years. Ten vendors currently supply hardware and software packages. (Business Week, June 2, 1980). The future likely holds computers with the capacity of today's minicomputers housed in bodies more similar to today's personal computers. In terms of employment consequences, the applications considered here are intended to cope with increasing complexity externally imposed, rather than to effect labor economies.

Banking. Banking and insurance might be treated as similar in many ways to the paper or information-processing activities of many government and business organizations. Labor saving applications in banking and insurance may indicate possibilities for similar labor savings in other paper-processing organizational units.

In banking, computerization of operations and EFT (electronic funds transfer) are complementary innovations, each making the other more salient. Specific applications listed by Evans are computerization of banking records and customer accounts; interbank clearing of checks by computer rather than checks; use of computer-read product codes at check-out stands. (Evans, 62-63). While none of these applications are specific to personal computers, banking industry observers have foreseen the use of microcomputers in banks for some time. (Lange & Kaplan, September 1975).

Computerization is also encouraged by the use of electronic message switching systems for wholesale EFT. Hall, a vice-president of Irving Trust, lists the four major systems (Bank Wire, Fed Wire, CHIPS, and SWIFT which, together, link hundreds of banks and handle hundreds of billions of dollars of transactions daily. Hall asserts that wholesale EFT services are necessary to meet international competition, reduce the banks' ability to use float, and push banks toward increased use of fees. Fees in turn require for their proper administration the better transaction records made possible by computerized banking operations. (Hall, 1978). This rather lengthy argument indicates the complexity of forces making it likely that computerization will find increasing applications in banking. However, the role of personal computers in banking is not so readily documented, nor are the consequences of personal computers easily distinguished. In Brennan's view, for example, microcomputers are adjuncts to larger machines rather than the primary innovative technology. (Brennan, 1975).

Insurance. Insurance offers a wide range of possible applications. A Business Week article estimates that paperwork between agents and companies costs 25% of premium income, or $38 billion a year, and that the companies have done little to reduce this cost. (Business Week, November 19, 1979). Existing insurance computerization has been devoted to the industry's extensive accounting requirements. Among the many potential applications noted by Robert A. Fischer are the following: claims handling including instantaneous payments in company or agent's offices remote from the policyholder's home; insurance program reviews machine-prompted at routine intervals and including questions and reminders for both customer and agent; on-line terminal access to home office systems from remote company or agent offices; auditing or client folios following changes in coverages; training of agents and administrative staff in new products and services; training of employees in procedures; image capture and processing to handle updating requests automatically, such as when a new car is purchased, including machine-generated letter follow-ups. (Fischer, 1975). Applications are more frequently noted in the life-health field than in the property-casualty field. Pell, for example, is among many stressing the usefulness of microcomputers to life insurance sales presentations due to the high cost of customizing the

software and the likelihood of a packaged program meeting "99%" of the agent's "presentation requirements." (Pell, 1980).

Ancipink, who covers automation for Best's Review, shows how interactive terminals in the agency allow better customer service (Patricia Ancipink, May 1978). Another Best's Review article notes that computers allow homeowners policies to be adjusted annually, instead of triennially, for inflation without a corresponding tripling of the workload. (Best's Review, September 1976). Another reported application is from a Philadelphia company which produces and updates its group plan books on an IBM 370/145, with a resulting high degree of accuracy and an estimated 25-30% savings. (Best's Review, September 1975).

In spite of the foregoing reports, Business Week estimates that few agencies use computers:

> "only a few hundred of the nation's more than 70,000 independent agents have installed even limited data processing hookups with their insurance companies." (Business Week No. November 19, 1979).

However, 8% of the agents have minicomputers or intelligent terminals, and the agents are buying minicomputers at the rate of 100 per month. A group of agents and companies have formed the Insurance Institute for Research to develop an industry-wide computer network similar to that available to travel agents but, the article notes, this is a long way off.

Word Processing and Office-Of-The-Future. This field has been the subject of much attention. Evans notes that word processing is particularly appropriate for typing large volumes of semi-standardized materials with small individualized changes. The actual impact of word processing, however, will depend "very much upon the uses to which it is put." (Evans, 1979 p. 65). Word processing may also lead to applications in filing and information retrieval that will free technical and administrative workers from dependence upon the services of secretaries and clerks. Electronic mail is another word-processing-related appliction. Evans estimates that in 1978 there were 100,000 word processors in Western Europe, and 400,000 in the U.S., with installations growing at the rate of 30% per year in the U.S. However, installations and utilization continue to be two different matters. (Business Week, March 24, 1980).

5.2. Summary of Applications Potential

Taken together, the applications possibilities noted in the preceeding pages touch most large organizations and many smaller ones such as drug stores, travel agencies and insurance agencies, as well as the individual consumer of automobiles, insurance, and many other products and services. The speed with which these applications will occur and diffuse, ultimately to affect the labor force and the consuming public is another matter. Each of these applications faces barriers to its design, installation, and diffusion. These barriers mitigate the consequences of the applications and complicate the estimation of employment impacts. The safest conclusion may be that nothing will happen as quickly as its advocates claim or its detractors fear. In the next section, some barriers to applications will be reviewed. These barriers are drawn from the literature reviewed for this study rather than from theoretical discussions of innovation.

5.3. Barriers to Applications

The fundamental barrier to computer applications is a configuration of

cost, time, and complexity all interacting. Several different studies comment on this cofiguration, which is driven by complexity with the consequence of high cost and unacceptable lead times for design and installation. Specific illustrations of one or another of these constituent factors can be drawn from bank trust operations, EFT, and office automation.

5.3.1. Cost-Time-Complexity Configuration

The complexity of the subject matter with which we wish computers to deal leads to high costs for the development of applications, lead times for design and implementation that are so long that obsolescence sets in before the application is implemented, and, possibly, non-functional applications. To begin with, Evans notes that microprocessor costs are only a fraction of the final product costs of a microprocessor application. (Evans, 1979). The point is also well-made by Brennan, who writes:

> (W)hen it can cost a million dollars or more to develop software and 'firmware' (program locked into solid-state memory) for a relatively simple device based on a four-bit microprocessor, the difference between $40 and $4000 for the hardware becomes meaningless in banking systems. (Brennan, 1975, p. 212).

Wetzler, a vice-president at Metropolitan Life, makes similar comments about insurance automation (Wetzler, 1978).

> Speaking directly to insurance, one of the industries often seen likely to be significantly affected in the near term by small computers, a McKinsey & Co. consultant notes that insurance involves "hundreds of variations and mountains of detail" as well as constantly changing regulations and multiple coverages. Basic insurance functions have exacting procedures that vary enormously, such as rating, coding, and policy writing. The Insurance Service Office (ISO) "Frequently changes rating and coding plans (including policy forms), thereby making previously automated work obsolete." (Erlanger, 1977 p. 108). The instability may also encourage centralization of computers to allow for rapid adjustment to changes rather than decentralized personal computers, especially freestanding ones. The difficulty of developing applications in such a turbulent setting is patent.

Another writer for Best's Review comments that some of the difficulty in developing applications needed by the insurance industry may result from a mismatch between the skills held by those who design systems and the needs of the industry: skills are in designing systems to handle large volumes of date in rigid formats on regular but lengthy schedules, but these are not the skills required "to handle the kind of management information needs so many companies now have." This article notes that new systems need a great deal of trial and error testing and adjustment so that the process of designing a new system may take three to five years to bear fruit. Such lengthy development times means that the systems are vulnerable to obsolescence from changing business conditions before they are complete. Additionally, as the system is being installed it can degrade the capability of the data processing department to perform existing applications. (Best's Review May 1978). Stillinger reports on an agency which automated some insurance lines but found the savings did not justify the investment. (Stillinger, 1978) 101-102).

While these problems are likely to be overcome in the long run — the argument here is not that sophisticated applications in insurance are impossible — much learning remains to be done, and the development and installation of the kinds of applications discussed here will be evolutionary, not revolutionary.

While many of the preceeding illustrations are from systems implemented on large mainframes, many of the important applications in banking and insurance which involve personal computers will be applications in which the small computers are used interactively with larger systems. The larger systems are needed for their storage capacity, for example. Thus the impact of small computers is critically dependent upon the design of much larger systems with which the small machines interface. The evidence seems to support the hypothesis that system cost, time, and complexity considerations will mitigate and moderate the impact of small computers on the labor force over the next decade.

5.3.2. Some Residual Moderating Influences

A number of other considerations are also barriers to rapid change. Some of the considerations noted in the literature are familiar complaints that bear repeating in the face of unbridled optimism. For example, much depends not only on an ability to provide useful software, but also on competent instructions on how to use that software. (Economist May 19, 1979). In insurance applications, Erlanger notes the dependence of the programmers on the cooperation of the underwriters. Relations between these two groups often break down due to the complexity of applications. (Erlanger, 1977). Stillinger found that users were quite satisfied with the services they were getting from a large computer system, and resisted accepting anything less on a smaller system. (Stillinger, 1978). Baron asserts that few rigorous studies of the return on investment in computers have been carried out in industrial countries. (Baron, 1976). On the other hand, Kaplan and Lange report the results of a 1976 survey which indicated that 45% of middle-sized and 55% of large-sized banks used ROI as a benchmark in evaluating computer applications developments, and 71% of the responding banks gave software an economic life of five years or less. (Kaplan, A. and Lange, P., March 1976). With short economic life and ROI evaluation, applications which might once have been given a green light may now be held up.

Unions are a force with which to reckon in implementing or adopting personal (or any) computer systems. While American unions have so far not resisted robotics strongly, (Business Week June 9, 1980), this need not represent the future response of unions as robots begin replacing workers on desirable jobs. To this point, corporate policies and collective bargaining agreements have assured displaced workers retraining and transfer at such robot users such as General Electric's Appliance Park; when this is not possible, attrition is used (Business Week June 9, 1980). With larger displacements, a strategy of attrition, which is equivalent to internalizing important social costs, may impede the adoption of labor saving computerization or microelectronics. Fiat, for example, has found that the Robogate system installed at two of its plants (and which has received widespread attention in the press) has raised productivity significantly but has had a disappointing return on investment "because so few workers were displaced." (Business Week June 9, 1980). In the telecommunications industry almost 100% of the nonsupervisory workers are unionized. Dymmel notes that contracts protect displaced workers. (Dymmel, Michael D., 1979).

Where unions are not strong — for example, in banking and insurance in the U.S. — worker resistance to computerization might be expected to be

less strong or well organized. Banks have been involved in automation for many years without any appreciable incidence of unionization. Coleman and Rose explain this by noting the emphasis by banks on job security and report that they do not know of any case where significant of numbers of workers lost jobs because of mechanization. They propose that threats to job security or changes in public policy are needed for unions to grow in banking. As of the time of the article, NLRB unwillingness to recognize small, bargaining units — specifically, data processing groups in a number of cases — made it difficult for unions to gain a toehold in banking. (Coleman, Charles J. and Rose, Jane A., October 1975). A change in this policy, and a consequent unionization of data processing or similar small technical units, might give labor organizations some effective leverage.

Early in 1979 British government computer staffs went out on strike to gain implementation of a pay comparability study. Only 1300 of the affected 330,000 union members went out on strike, but many critical functions, such as tax collection and payments to contractors were stopped. (Business Week March 12, 1979). At present in the U.S., workers in banking, insurance, and other non-governmental office industries would find it difficult to take comparable action to protect themselves against adverse consequences of computerization.

5.4. Three Skeptical Illustrations

Trust operations of banks, electronic funds transfer, and office automation are three subjects which have received much attention from those advancing computerization of financial services. Each field encounters great difficulty in meeting the expectations of advocates of automation, however, but for different reasons: complexity, external factors, and conceptualization, respectively.

Trust Accounts. Trust department automation is representative of the complexity which can be encountered in fiscal services. The most recent report found is several years old and may be somewhat dated. The problem structure, however, should not have changed in the past four years.

Brennan presents trust departments as composed of individual accounts, each different and each requiring detailed, perfect, permanent records. The size of the problem is indicated by the automation effort of one bank, which dedicated an IBM System 370, 40 CRT terminals, 400 programs, and 20 data bases. Available packages run as large as 100 programs. Only 1/3 of the 4500 trust departments had any automation in 1976; the development times of 10 years and more for automating trust services have already been mentioned. (Brennan, February 1976).

It should not be assumed that trust automation is not successful; the points to be made here are different. first this is a very complex, long-term effort. Second, it is based upon large computers or multiple minicomputers, as a strategy. In either case, a lot of computing power is necessary for this and other financial service jobs. Third, while personal or microcomputers seem likely to find a place in trust automation — though no mention of this specific application for PC's turned up in the literature reviewed — they exist in a dependent role relative to larger machines because of the magnitude of the automation effort.

Electronic Funds Transfer Systems. Not too many years ago, 1980 was considered to be a target date for the cashless checkless society. The technology is available, and is relatively less vulnerable to labor cost growth than is the conventional manual processing of paper. (Waldron and Ball, 1980).

Among the EFT services possible are credit authorization, check

verification, check guarantee, file look-up for employee access to individual accounts, deposit, cash withdrawal, bill payment, purchase payment, transfer of funds among accounts, cash advances, and credit purchases. (Waldron and Ball, p. 440). Each of these services has been automated, but not all are widely used.

Cost is only one reason. Awad, several years ago commented on the low cost of banking transactions and the difficulty of realizing cost savings that are projected in analytical studies. (Awad, 1977). Waldron and Ball more recently find the same barrier. The capital investment in hardware and software, and the yearly maintenance costs, make breaking even on simple services very difficult. They estimate that currently, breakeven on check verification requires between 5000 and 10,000 terminals each handling 2500 - 5000 transactions per month. (Waldron and Ball, p. 45).

The interaction between the customer and the machine creates other barriers. Some customers are reluctant to use a system they cannot argue with. The need to remember a password is also a barrier to use by retail customers. Fear of unauthorized use, to the disadvantage of either customer or bank, is a barrier to authorized use. Concerns over reliability — what happens if a deposit is not recorded and a customer's checks bounce? - inhibits use also.

Even were these thorny customer/technology issues resolved, other problems remain. Somewhat less specific to the technology and more related to government policies are questions of privacy. According to both Awad, and Waldron and Ball, this is a persistent barrier to customer acceptance of EFT systems.

A major barrier to the widespread use of EFT systems, is the lack of resolution, through public policy or otherwise, of the question of who will organize the business, in what way, and to whose benefit. Basic questions of territory, competitivenes, exclusiveness, regulatory responsibility, and protection of small banks remain to be addressed. The fact that these same issues appear to impede EFT development in 1977 and, still, in 1980, suggests that development will continue to lag the expectations of EFT advocates and to impact the financial services workforce at a gradual pace. Nonetheless, Waldron and Ball note, many large employers benefit financially from EFT services such as automatic deposit of salary and pension checks and large retailers benefit from check verification services. These large organizations will maintain momentum behind EFT systems in the years to come even if retail consumers prove less enthusiastic than once hoped.

Office Automation. Strassman, of the Xerox Information Products Group, considers that movement toward the more efficient and heavily capitalized office of the future has turned out to be more difficult and complex "than the changes that were necessary for industrialization." He writes:

> Current discussions focus too completely on technological developments; serious planning for the transition to office environments where the latent power of computers could be fully realized is being largely neglected. (Strassman, 1979--80).

Like other observers of office automation, such as Baron, or Coleman and Rose, Strassman recognizes that many repetitious office tasks have been automated before the coming of today's office-of-the-future technology. (Strassman, p. 56). He takes this realization one step further by asserting that an increasing fraction of clerical workers are in jobs requiring symbiotic relationships with "knowledge workers,"

professional/technical/managerial/administrative. He claims that "future opportunities for automation will depend more on fulfilling the needs of knowledge workers than on eliminating monotonous and repititious clerical tasks." (Strassman p. 56). However, noting that knowledge workers spend the majority of their time communicating with each other face-to-face, in meetings, on the telephone, and by writing, Strassman concludes that available technology is not terribly relevant. He writes:

> Electronic devices currently available have little direct leverage on the heavy communication loads of knowledge workers. Indeed the impact of office automation on their personal working habits has been negligible. This is because the communication of knowledge workers is largely unstructured and ill-defined. (p. 58).

Contrary to this interpretation of the requirements of office automation, Strassman comments that the tendency in automated information handling has been to follow an "industrial model" of standardizing unit transactions so that computers could build up to complex functions from simple elements. This is well adapted to passenger reservations, payroll, or order verification, but not to the symbiosis of clerical and knowledge workers. The industrial paradigm of information automation stresses these standardized transaction volumes, and simple systems for analyzing cost and value considerations so the most economical configurations can be implemented. Large systems have been built on such a model.

Strassman sees that such systems fall victim to their own complexity as they grow. Eventually, so many transactions must be treated as special cases that the exceptions overwhelm the human system. Error rates grow and error corrections become very costly — often an error costs 20 to 50 times as much to correct as the original transaction cost to handle. Specialized organizational units are developed and staffed with information workers in order to cope with the errors and exceptions. Each unit develops its own communication linkages, budget status system, and role, which it defends against changes even as its task is to cope with change. The end result is large, unwieldy bureaucracies, resistant to change, and composed largely of hard-to-evaluate overhead units.

Strassman argues that office automation requires a reconceptualization of what offices do, and a restructuring of office work. His particular proposal, for "information middlemen" lodged between diverse customer/clients and functional staffs of the bureaucracy, is of less immediate interest than his rejection of current office organization. His representative example is of the airline reservation clerk capable of making flight, hotel, or auto rental reservations all over the world. But he notes that it took 15 years for these systems and organizational structures to emerge for the airlines.

More to the point are the tasks which he sees remaining to be accomplished. He enumerates among them: telecommunications protocols, data definition conventions, access to distributed data bases, privacy, security against fraud, indexing of information, synchronizing learning levels of interacting people, unambiguous expression of procedures, and procedures for approving changes without encountering the problems posed by current organizational structures. Further, he argues that progress in office automation requires that information be converted more completely into a priced commodity rather than something to be hoarded for power and status advantages.

Viewed in this light, it is not surprising that Strassman considers real office automation to be a task comparable to the development of industrial era "commercial codes" such as the "banking system" and

"standardized engineering specifications." Strassman asserts that to go beyond the automation of repetitive clerical functions, major reconstructive surgery on our organizations and ways of doing business will be required. If he is right, the employment consequences of office automation will be fitful and hesitant for many years into the future.

6. Impact of Personal Computers on Work, and Changes in the Nature of Work

The main policy-relevant conclusion from a review of the impact of computers on employment is that policies must be considered in the context of employment as it is likely to be viewed in the future rather than as it has been viewed in the past. The future holds a view of employment which is separate from work, and in which income, production, and recognition are demarcated and separable.

Employment is an instrumentality, not an end-in-itself, for an increasingly large number of people. In the two-plus income household, employment for an individual is more discretionary in the short run than it has been in the one-income household of the past.

A second caution deriving from this review is that policy not be made based parochially upon a model of the desirable work setting projected by well-educated, well-paid professionals. There is substantial diversity in what people want from their employment situations, yet government agency executives and staff analysts are quite a bit more homogeneous in social outlook and location than the general labor force. Again, a major foundation for employment policy must be what diverse persons want from employment. This "market" perspective is difficult to maintain in the face of expert opinions regarding what people really want or need.

Many thoughts abound regarding the effects of computers — personal or otherwise — on work. Writers emphasize decentralization, skills polarization, more informed management, greater interdependence, more interesting work, and creation of new hierarchies. For the most part, little data are available, nor are the analyses carefully thought out or theoretically guided. When speculating about the impacts of personal computers, one ought not to become too enamoured of contemporary definitions of work, however. In this section, some common themes will be reviewed first, and then some thoughts about the changing nature of work will be offered. Critical to this latter part is the separation of production, income, and status which, this author believes, is more advanced than one first realizes.

The common thoughts on this matter are sometimes contradictory, but bear repeating anyway. In general these thoughts can be divided into optimistic and pessimistic ones. Computers — especially personal computers — are seen as bringing about the prevalence of the kinds of work settings which professionals and well educated people think they desire: interesting work, serving people's needs, with lots of good information available, in a social environment of creative interdependence, and with a high degree of decentralization and personal autonomy. On the other hand, computers are also seen as creating a polarization of skills so that work is divided into elite and drone jobs with little in between. Computers are seen as creating new invidious status hierarchies, including an empire-building computer elite which gains power through mystification until it becomes parasitic rather than productive. A final consequence is the reduction of white collar workers to "variable costs" much as blue collar workers are often treated. Several articles bear directly on these visions.

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6.1. Optimistic Projections

One common projection of the work impacts of computers, especially when small computers and related devices such as POS devices are considered, is the development of totally integrated work environments. Evans provides one version of this vision:

> The ultimate in the development of real time systems is the linking of sales, stock control, production control and ordering whereby all operations within an organization become computerized. (Evans,1979).

Another common idea is that computers increase the quantity and quality of data available to managers, either in real time or through convenient search routines. This is normally viewed as advantageous, though Ackoff cogently argued the opposite a decade ago. (Ackoff, 1970).

Computers may provide managers with more data or with different information: but, as the general semanticists are fond of asking, is this a difference that makes a difference? One insurance article offers a picture of better service, better operating results, greater productivity, and employees with more varied and satisfying work. In this report, underwriters are provided with information that affects policy renewal decisins so that the individual underwriter concentrates on initiating business and making decisions. Underwriter turnover is reported to have dropped significantly (Best's Review, 1976). Short of substantially more research using very careful conceptualizations, the safest conclusions are that computers, personal and otherwise, provide managers with more and different information than they would otherwise have. The consequences of that information in terms of decision quality are much harder to measure.

A report on cash management systems at Chase-Manhattan Bank claims that the computers eliminate "much of the clerical drudgery." (Osterman, May 1979). Given the learning required by computer systems, many people may very well find their jobs becoming more interesting. The novelty may wear off for some people once the system is mastered, caution is in order until more systematic studies are completed.

Sanders, in an article on future structures for life insurance companies, sees increased importance for branch managers. Branches will become highly independent. Branch managers will become "the company in that territory," with full charge of marketing and administrative services, and "perhaps even profit center responsibility." Distributed processing, using interconnected minicomputers will make this decentralization possible. (Sanders, May 1978).

Related to decentralization and to improved social environment at work is the projection of greater interdependence among employees. Rudy sees closer relations between claims adjustors and policy underwriters because of computerization: the former can now provide the latter with up-to-date information on the incidence and cost of losses. The underwriter has an incentive to obtain a more complete property description from the client, and to communicate this to the claims adjustor. The two then interact around renewal time as well. This cooperative interaction can be prompted by a computer, which can also perform calculatins and store information. (Rudy, 1976). Particularly when the interaction is computer prompted, new forms of workplace cooperation may well emerge. The meaning of this, in terms of quality of work life, is not self-evident. However, it is not hard to imagine many kinds of effectiveness improvements resulting from computer-prompted

cooperation on the job.

Most of these positively valued changes in work involve vague terminology and hard-to-measure concepts. Also, the evaluative dimensions are not always clear: productivity, satisfaction, self-actualization? Taken together, however, these projected changes configure into a model of work which many writers have advanced in other settings as modern, satisfying, and institutionally and socially functional. Therefore, in spite of the formidible methodological problems inherent in the undertaking, the question of whether or not computerization furthers this model of working life could be profitably investigated by a government agency truly interested in the quality of working life.

6.2 Pessimistic Visions

There is a negative side, of course, and it too bears investigation. Here, however, the variables are often more concrete. One concern, for example, is with the costs of data processing staffs — the "systems analyst, systems programmers and applications programmers, plus console operators, peripheral device operators, a technical support group to service the operating system language, data control clerks, scheduling clerks, etc." (Goldbeck, 1974). Smaller computers are seen by the writer of this article as an antidote to staff imperialism.

The availability of distributed processing and small, free-standing computers may also help overcome what Goldbeck sees as invidious priority rules in which small jobs never receive attention within a company and small companies get bad service on shared equipment or systems.

Applications themselves may reinforce existing status rankings or create new ones. Clark praises the implementation of access and call-reminder based status hierarchies in an article on computerized management of long distance telephoning in an insurance company. He reports, for example, that higher executives avoid the nuisance of being periodically "beeped" while on long distance calls. (Clark, 1977). Related to this might be the computerized surveillance of employee productivity, work pace, and error rates which Evans notes as a realistic possibility for workers in regular interactions with computers. (Evans, 1979). Such surveillance can be tightened or loosened according to the subject's status, and would make daily use of a personal computer a very mixed blessing.

Evans, among others, notes the possibility of "skills polarization" within the labor force. In this situation, as a consequence of computerization, the workforce is divided into two groups clearly differentiated by their computer capability. He forsees an elimination of skilled manual labor, such as maintenance and repair, tool setting. (Evans, 1979). Supporting this view is the analysis by Best and Stern of new job creation in the U.S. They report that new jobs created during the decade of the 1960's were disproportionately in the low-skill, low-pay occupations. (Best, and Stern, 1977). Along with this possible skills polarization has come a democratizing factor however: employment displacements are occurring in stable as well as high-turnover occupations, (Dymmel, 1979), and among white-collar as well as blue-collar jobs. (Roomkin, 1979).

Rather than projecting computerization, and particularly microcomputerization, as leading to the realization of the professional's preferred worklife, one might also project computerization to lead to greater employment instability for professionals, skills polarization, employee surveillance, and the development of new invidious status hierarchies. Both visions are highly generalized and difficult to test empirically. And both

may accept too much of the conventional view of work. As an antidote, some alternative views of work will next be presented.

6.3. The Changing Nature of Work

Employment is a political demand, a social status and role, an economic means, and a psychological satisfaction. In developing policies regarding employment, collective need and individual demand must, at a minimum, be separated. Some changing features of employment in the aggregate can be reviewed, then the question of linear life plans will be raised. The surplus of college graduates will next be considered, and then the constituent parts of work will be examined.

Many alternatives to normal, full-time, continuous employment are being discussed. Best and Stern advance shorter work weeks, job-sharing, part-time jobs in highly skilled occupations, guaranteed minimum vacations, reverse seniority layoffs, paid educational leave, voucher adult education, work sabbaticals and other techniques for redistribution of work, education, and leisure. (Best and Stern, op. cit., p. 9). The Lifetime Learning Act of 1976 provides authority for government efforts in the area of paid educational leave. (Nollen, 1978). The Dutch government has attempted to introduce work sharing, and other European governments are pursuing policies which ultimately have the consequence of redistributing employment among social groups. (Europe's Jobless: No End in Sight?". Duns' Review 110.1 July 1977). All these innovations in employment are receiving increasing attention and foreshadow changes in working that should be considered when attempting public policy innovations to cope with changes caused by microcomputers.

Concern with what in Europe is termed work humanization and in the U.S. is recognized as "quality of worklife" may forshadow a decreased concern for job displacement if the lost jobs are ones which do not meet contemporary standards for humane work. Such a movement represents a shift away from traditional union concerns with pay and job protection, and toward a concern with the broader life of the worker. (Kasselow, 1977).

Plausibly related to this ferment is a growing questioning of the "linear life plan" of education, work, and leisure. Nollen argues that this sequence is no longer desired by many people. (Nollen, 1978).

At the same time, part-time work has become increasingly common, especially among women, students, and older persons. (Cain, March 1979). Part-time work is a function of social insurance: the lower a man's "primary insurance amount," the more likely he is to continue working. (Rones, 1978). Further, some occupations are more amenable to part-time work than others: sales and service jobs are, while craftworkers and operatives are not. (Rones, 5). Since small computers used in communication with larger systems may permit new ways of working at home, they may also expand the possibilities for rewarding part-time work as well.

It would be fortunate if personal computers were to facilitate part-time work, job sharing, and other employment innovations, particularly in jobs requiring advanced education or skill. As Best and Stern (1977) note, the production of college graduates exceeds the growth of professional and technical jobs. This excess turns up repeatedly in Bureau of Labor Statistics projections. (Wool, 1976). Contrary to expectations of "skills polarization," which were noted earlier, Wool's analysis indicates a growing shortage of people to take the growing number of "lower level" jobs. Again, such jobs may be more palatable as part time than as full time work. And, if these jobs can be eliminated through automation, the nation might mourn less than were they to otherwise go unfilled. Wool notes that these jobs are functionally essential to the economy and society, as they involve food

processing, shelter provision, care of the sick and aged, and a wide variety of housekeeping and production functions. (Wool p. 26). Generally, these jobs are not in the goods producing sector, however, and it is this sector which has proven most amenable to mechanization.

The shortage of workers for low-level jobs, in the face of high unemployment rates, forces consideration of the nature of work itself and what people want out of employment. An unstated assumption of this culture is work as an end in itself. This assumption may fit comfortably upon the kinds of people who manage large organizations or use sophisticated computers. But the decreasing labor force participation of men in recent years in the face of growing income maintenance programs suggest quite the opposite is true for large numbers of potential workers. To be direct, for many people work is a means not an end: government policies based on the notion of work as an end are imposing a value of less than pervasive generality upon a workforce for which it is increasingly irrelevant.

The distinguished development economist, A.K. Sen, identifies three aspects of employment: Income to the person, Production to the society, and recognition for the person. "Employment," Sen writes, "gives a person the recognition of being engaged in something worthwhile." (Sen, 1975). This separation of income, production, and recognition is inherent in the notion of disguised unemployment: when a person leaves a job, others easily perform his task assignments without replacement. In this case, income and recognition are distinct from production, for the worker is paid and recognized, but is clearly not truly productive. Sen also asserts that poverty is a function of social arrangements, not of employment. He writes:

> Poverty is a function of technology and productivity, ownership of the means of production, and social arrangements for production and distribution. To identify unemployment with poverty seems to impoverish both notions since they relate to two quite different categories of thought. (Sen, p. 49).

In this quote, income and production are severed, a disjunction perhaps more readily apparent for the "idle rich." If the two are not kept distinct, Sen notes, erroneous policies may be pursued, as when government seeks extra work for a person already working hard, but who is poor. An income definition of employment would have income conditional upon work performed. Other definitions of employment are possible, however. Employment, as the term is commonly used, involves a strong element of recognition. Criminals have income dependent upon their work (such as stripping and selling automobile parts) but people in such occupations are not usually recognized as "employed." On the other hand, some volunteer efforts garner for those who make them a degree of social recognition similar to that accorded (in some circles) to persons in high status jobs.

Here the illustrations have been kept at the individual level. At the aggregate level the issue is more salient. Mouly suggests that employment is very difficult to define in a way that is valid across cultures. Employment, he asserts, "implicitly refers to a particular type of economic and social organisation." The notion was developed in a market economy "tailored to wage and salary workers." (Mouly, 1977). In an advanced collectivist economy, Mouly continues:

> . . .in which there is only a weak link, if any, between productive effort and the right to its fruits, that is to say where income from production is replaced by transfer payments, the very notion of employment becomes tenuous. (Mouly, p. 2).

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In the United States at present a very large number of people are supported by transfer payments. We may have reached this state through the back door of pension plans and social insurance schemes. The vast number of persons supported by transfer payments cannot be denied, and alters the de facto notions of employment which underlie any government policy's design to assist those workers and others potentially employable who have been affected by computers. Only in a strict market economy is the definition of employment easy — by price paid.

In general, the definition of employment is determined by broad policy aims and development goals, according to Mouly. He emphasizes this with an illustration that makes it clear that American thought on the subject of full employment has not given much attention to the social policy innuendos of the subject. He writes:

> For example, if power is the dominant aim (as in a war economy), the desirable limits of employment — i.e., full employment — will not be reached until every able-bodied person is at work, irrespective of individual wishes and aspirations. By contrast, in a welfare framework where leisure and consumption are preferred, the economically active population will shrink and the level thought to constitute full employment will be lower." (Mouly, p. 3).

Mouly also believes that current discussions of employment ignore the heterogeneity of the labor force of industrial countries, and suffer from individualist fallacy. Terms like full employment, level of employment, unemployment, and the like are "catch-all notions hiding a multiplicity of situations each calling for specific action." Here he sides with the "structuralist" and against "aggregate demand" notions. Further, each worker is a member of one or more groups, at a minimum usually a family unit, and that group, rather than the individual, is the economic unit. (Mouly, p. 4; but see also the University of Michigan Income Dynamics Panel Studies).

Mouly cautions specifically against creation of "non-problems" through the careless and culture-bound use of employment terminology. The real issue is who wants, and who can do, what kind of work; and who needs it done. "Employment," he writes, "is not an end in itself, it is a means of using resources so as to satisfy human needs directly or indirectly." (Mouly, p. 5).

Elaboration of the implications of the notions of Sen and Mouly for the question at hand, public policy response to the impact of personal computers on employment, requires far more data than currently are available. Here, however, one message is clear: caution. The growth of public and private social insurance arrangements in the last generation, the changing demographics of the workforce, and the general lack of penetrating debate over basic conceptualizations of employment all mitigate against hasty politics when the impacts of personal computers (or of computers in general) upon the workforce are arguably slow and fragmented.

7. Politics of the Unemployed

Before considering government policies to deal with the employment consequences of personal computers, one might well ask what those affected demand for themselves. This short section reviews very briefly some recent empirical evidence about the unemployment. (Schlozman and Verba, 1979). This evidence is taken from a single but impressive study in which a regular

population sample and a special sample of jobless persons produced 1370 interviews, 571 with jobless persons. Economic and political attitudes were examined in light of employment status and social status measures. The findings affirm a lack of "class consciousness" and a strong faith in "the American Dream" on the part of the unemployed as well as the employed. Rather, it is the educated young, not the unemployed poor, who hold radical attitudes. (p. 230). Since the argument in this book is unfolded carefully, brief summary is risky. However some findings can be summarily presented.

First, in general, Americans believe in the "American Dream," an "individualistic vision of advancement" rather than a class conscious one. (p. 128). No relationship between this belief and an individual's class identification or employment status is found. Second, "in a variety of ways our data suggest the existence of a significant disjunction between the experiences individuals have with the American economy and their more general views of American society." (P. 155-156). In fact, those expressing a desire for self-employment are slightly less satisfied with their personal economic experience than those not expressing this desire. (p. 160). "Neither joblessness nor social class is related to a sense of class consciousness." (P. 224). And class consciousness, as measured, has little association with economic policy preferences. (p. 226). The evidence is that American society today is less clearly differentiated politically than it was in the 1930's by economic circumstance and belief. "Political beliefs seem to have been uprooted from their previous grounding in objective social circumstances and appear to be autonomous from the traditional demographic bases that structured them in the past." (p. 230). Regarding attitudes, the following four conclusions are drawn: economic position and individual satisfaction are related; beliefs about the workings of the social system, opportunity, and relations among social classes have coherence; personal experience and social ideology are <u>not</u> related; personal economic circumstances and policy preferences are <u>not</u> related. (p. 231). This collection of findings leads to an expectation of few political demands <u>from the unemployed</u> to rectify their condition but, possibly, vigorous demands for such action from those without an immediate stake. With such attitudes and beliefs failing to differentiate the employed from the employed, it is not surprising that political participation also fails to sharply discriminate between these two groups. Studies from the Great Depression found that the unemployed tended to withdraw from social participation and organizational membership. Today, however, the unemployed express similar degrees of interest in politics — they are equally likely to watch television and more likely to participate in a political demonstration, if slightly less likely to read the newspaper or vote in the 1972 election. These differences disappear largely when occupational level is controlled. (p. 241-245). The evidence indicates that "any difference between the employed and the unemployed in their amount of political activity is a function of the sociological characteristics of the unemployed rather than a result of the experience of unemployment." (p. 245-6). Activity also does not vary according to duration of unemployment.

Regarding voting power, the 1976 electorate contained more unemployed persons than it did farmers, Jews, residents of eight Rocky Mountain States, or combined members of the three largest labor unions (UAW, USW, and Teamsters). In half the states, including the nine with the greatest population, the presidential electoral majority was less than the number of unemployed in the respective state. (p. 248) Voter registration rates account for the differences between employed and unemployed citizens in turnout. (p. 251). Current Population Census studies indicate no special political disaffection of the unemployed. (p. 252). In general, differences between the employed and unemployed in political or social participation are accounted for by

differences in the social composition of the two groups. But using a variety of measures, Scholzman and Verba find no evidence of a withdrawal by the unemployed from organized activity. One exception to this is that unemployed persons are more likely to withdraw from union activity the longer their spell of unemployment. (p. 259-261).

Interviewing manpower policy influentials in Washington and elsewhere, Schlozman and Verba find exactly what their survey research led them to expect:

> There was virtual unanimity among those with whom we spoke that our conclusion about the political quiescense of the unemployed was warranted.
>
> They are, in the words of one government official, 'a political zero.' (p. 265).

No serious lobby group represents the unemployed, although there are groups advocating full employment bills such as Humphrey-Hawkins. These are unbrella organizations, however, the constituents of which have their own special purposes and clientel. Abstract concern with the unemployed is high, but concern evaporates when costs of ending unemployment are broached. (p. 289).

This study, which is the major recent piece of research on the subject, suggests that the unemployed do not now, and are not in the near future likely to, constitute a political force or issue of any magnitude. In the past unemployment has inured to the benefit of Democratic candidates in general, and against incumbents -- slightly. (p. 281). But there is no evidence that familiar electoral actions or public policies can have any impact on these results, or on the outcomes of elections. The politics of the unemployed, as found by Schlozman and Verba, makes a powerful cynical for their "benign neglect" by public policy.

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CHAPTER 6
THE PERSONAL COMPUTER AND INTERNATIONAL TRADE

1. Background

Because of their applicability to a great variety of information tasks in developed and developing countries, personal computers can be expected to have broad impacts globally. The following sections treat some of the implications of these possibilities on international commerce.

1.1. Developing Trends in International Economics

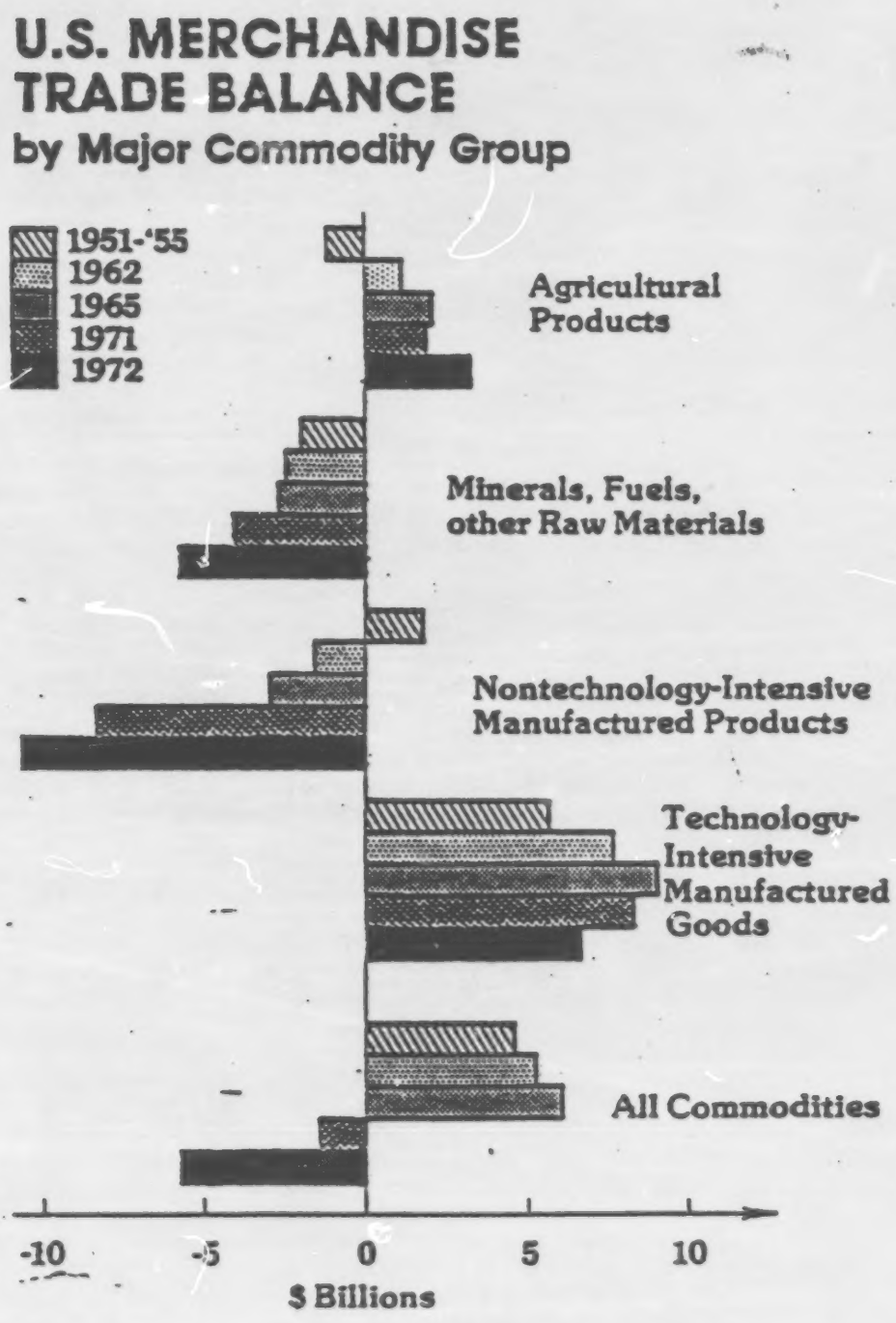
The background of the issues concerning the effect of personal computers on international trade with the United States is as follows. Since World War II at least, and possibly before that, the United States has been the dominant international power for a few fundamental reasons: it has had the best equipped and trained armed forces in the world and, for much of this period, it was a net exporter of agricultural products and manufactured goods. However, over that same period up to the present, we have steadily increased the flow of imports relative to exports to the point where we have had a net deficit of exports over imports over most of the last decade. Clearly, part of this deficit is due to the drastically increased price of petroleum in our automobile-based economy, but this is not the only reason.

1.1.1 International Balance of Merchandise Trade

The two mainstays of our export trade over this entire period have been agricultural and technology intensive manufactured products. Figure 6-1 shows the composition of our export trade over the period 1951 to 1972. These figures show the increasing proportion of our export trade in these two areas, with agricultural products continuing to make a basic contribution. It is the other area that is of concern to us here. Our comparative advantage in technology intensive products has been steadily diminishing, as is reflected in the annual growth rates shown in Table 6-1. The major components of this area of high technology products are armaments, aircraft, chemicals, computers and electronics. The trade category of consumer electronics has experienced severe erosion over the last decade. In the category of computers and business machines, on the other hand, the U.S. has managed to keep a relatively constant comparative advantage against international competition. The central question to be addressed here is whether this comparative advantage will continue, increase, or decrease. If it increases, clearly the economy in general will be better off because the increase will act to lessen our international deficit of trade unless increases in trade in these areas ultimately act to induce compensating decreases in other areas. If the advantage stays about the same, we will at least not suffer any increase in our balance of payments deficits resulting from this sector of the economy. If, on the other hand, there is a decrease in our comparative advantage in computers and business machines, then we can experience increasing difficulties.

Japan, in particular, has grown to be a dominant force in the field of consumer electronics. The majority of stereo systems, television sets and related electronic appliances sold in the United States are of Japanese or Korean origin, primarily contain parts from those two countries, or are manufactured by U.S. based plants owned by Japanese firms, even in those cases where they are sold under U.S. brand names. Yet, twenty years ago, almost the

FIGURE 6-1



/source: Boretsky, 1978, page 20/

Average Annual Growth Rate
% Per Year (Current $)

COMMODITY GROUP	1951-1955 to 1962	1962-1971	1971-1972
Agricultural Products			
Exports	4.6	4.0	22.1
Imports	-1.2	3.7	12.1
Minerals, Fuels and Other Raw Materials			
Exports	4.9	5.5	36.8
Imports	3.2	5.2	22.8
Not Technology-Intensive Manufactured Products			
Exports	-0.6	5.5	-3.2
Imports	10.4	10.0	21.9
Technology-Intensive Manufactured Products			
Exports	4.4	8.2	9.7
Imports	10.8	18.3	25.4
All Commodities			
Exports	3.4	6.7	12.7
Imports	4.2	9.7	21.9

TABLE 6-1
TRENDS IN U.S. MERCHANDISE TRADE BY MAJOR COMODITY GROUP
Selected Periods, 1951 - 1972

/SOURCE: Boretsky, 1978

entirety of the U.S. market and a reasonable proportion of foreign markets in these areas were dominated by U.S. firms. The erosion of the U.S. domestic market by Japanese competition has continued essentially unabated. Furthermore, the Japanese have made a national commitment to rival or dominate the United States in information processing technologies in general.

This ambition is not restricted to Japan. Other developed countries, recognizing the role that information processing technologies are likely to have in their futures, also have increased the attention they are paying to this area. Great Britain, for example, has a national committee comprising representatives from industry and the government to consider strategies for becoming dominant in the general field of office automation. Most Western European countries have plans for entering the semiconductor market in one form or another. The Japanese have begun their thrust toward the U.S. computer market by the introduction of various computer peripherals, such as printers and disk drives, and in microelectronics (for example, Nippon Electric, in the third quarter of 1979, had 5% of the US market for semiconductor memories, in general, and 20% of the 16K RAM market). (Business Week, 3 December 1979)

It is important to stress that the computer products import competition picture in the United States is not one of the market's being flooded by poor quality imports. On the contrary, in most cases the quality of the imported technology is quite good, often demonstrably superior to U.S. products at the same price, according to Hewlett-Packard Co. (Computer World, 26 May 1980). Hence, the U.S. consumer, seeking to get the best quality product for his money or the lowest price for a given level of quality, will select an imported product because of this advantage. This relates to the basic economic fact, generally not covered in textbooks, that for every product there is a price-quality-quantity demand surface. If a manufacturer can make a product at a higher quality for the same price, quantity will increase, sometimes substantially more than would be caused by a decrease in price at the original level of quality (See Figure 6-2). The consumer does not perceive the various forms of governmental intervention which may act to make the situation the way it appears to him. The following sections will treat the possible trends in import competition and governmental intervention in the market process as it relates to two aspects of the international trade market: importation into the United States of personal computer products from other countries, and exportation from the United States of similar products and/or manufacturing "know-how" to other countries.

A fundamental concept in the economic theory of international trade is the law of comparative advantage propounded by Ricardo in 1817. This law, like many others of economics, assumes free market conditions. In it each element of the market (each country, for example) produces only those products which it can produce best, that is, for which its means of production are relatively most efficient. It sells those products to other market elements in exchange for the products which each of the other elements can produce best. This way, all products are produced at optimal efficiency and distributed equitably through the processes of the free market. Each element finds its particular niche in the economic tapestry of the world. This law has been a dominant influence in recent U.S. international economic policy. In the past, the United States has had a comparative advantage in many sectors of the international economy. The constituents of the U.S. economy which have made this possible have been its abundant natural resources and its high level of technological advancement (in consequence of a limited supply of labor). There are many within the U.S. public and government who believe that the U.S. still has a significant comparative advantage over the rest of the world in the primary net export areas just discussed. However, as was just

Published

Trade data as reported	1970	1971	1972	1973	1974	1975	Average annual growth rate (70/75)
Exports	417,021	370,528	469,644	848,454	1,247,498	1,053,495	20.5
Imports	157,464	179,092	330,277	618,613	961,338	802,687	38.5
Balance	259,557	191,436	139,367	229,841	286,160	250,808	

Adjusted

Exports (less content of 806.30/ 807.00)	417,021	370,528	469,644	848,454	1,247,498	1,053,495	
	-78,409	-81,255	-127,346	-185,637	-310,359	-291,718	
	338,612	289,273	342,298	662,817	937,139	761,777	17.6
Imports (less US content of 806.30/ 807.00)	157,464	179,902	330,277	618,613	961,338	802,687	
	-78,409	-81,255	-127,346	-185,637	-310,359	-291,718	
	79,055	97,837	202,931	432,976	650,976	510,969	45.3
Balance	259,557	191,436	139,367	229,841	286,160	250,808	

TABLE 6-2

PUBLISHED AND ADJUSTED U.S. TRADE DATA FOR SEMICONDUCTORS, 1970-75 (THOUSANDS OF DOLLARS)

/SOURCE: Bureau of the Census
Foreign Trade Data Printouts, 1970-75/

illustrated, there are significant signs that our comparative advantage is rapidly diminishing; in fact, that the rate of decrease in comparative advantage in these sectors is increasing. (Boretsky, 1978)

> As Tesar states (with emphasis mainly on mechanical technology): Careful review of the economic indicators, especially those dealing with manufacture of consumer goods, indicates that a long-term deterioration has been underway and that we are now exhibiting a major technological deficit costing us a minimum of $10 billion per year. This deficit could easily deteriorate in the next three years to a $40 billion deficit in our trade in manufactured goods associated with mechanical technology.(Tesar, 1979)

In the years since 1972, the US has experienced a trade surplus in many areas of manufacturing. However, a good portion, if not all of this, may be attributed to the influx of purchases from OPEC nations which were engaged during the seventies in spending petrodollars. At some point in the mid-1970s, the OPEC nations became saturated with US products, whereupon the decreasing US comparative advantage again began to become apparent, according to Tesar. This shift is not confined to mechanical technology. The trade balance even in one of our most technology intensive industries, semiconductors, is being reduced by foreign competition, as shown in Table 6-2.

1.1.2 History of US Policy in International Trade

The two hundred year history of the United States provides a good example of the development of international trade economic policies in conjunction with the economic development of the nation as a whole. When the United States was first established as a nation, it was a resource-rich, but capital-poor country. The immediate task of the Federal government was to develop policies to allow infant US industries to grow to a level where they could successfully compete with the industries of other countries. In fact, the first act passed during the first session of the first United States Congress in 1776 was tariff legislation. The tariffs during this initial period provided a dual purpose: protection of the infant industries and a major source of funds for the operation of the Federal government. For most of the 19th century, and well into the 20th century, tariffs have formed a crucial part of the largely protectionistic trade policy of the United States (Figure 6-3).

During the latter part of the 20th century, the contemporary economic ideas of the validity of the law of comparative advantage and the associated desireability of free international trade have become the dominant trade policies within the United States. A milestone in this development was the Reciprocal Trade Agreements Act of 1934. This means for developing multinational reciprocal agreements on the reduction of tariffs received further momentum with the entrance of the United States into the General Agreement on Tariffs and Trade (GATT). This progression has not been without its occasional switches in direction, however.

> During the fifties, the liberal advances made with GATT at the end of the forties were eroded by pleas of special circumstances. As the European and Japanese economies recovered, two things happened simultaneously: sympathy for their needs declined as the needs themselves declined, and as the strength of their industries grew, their imports to the US also grew. Perception of the impact of these imports was probably sharpened by the rather slower rate of growth of our own economy. (Bauer, et al, 1974)

Nevertheless, the primary trend has continued toward the reduction of tariff

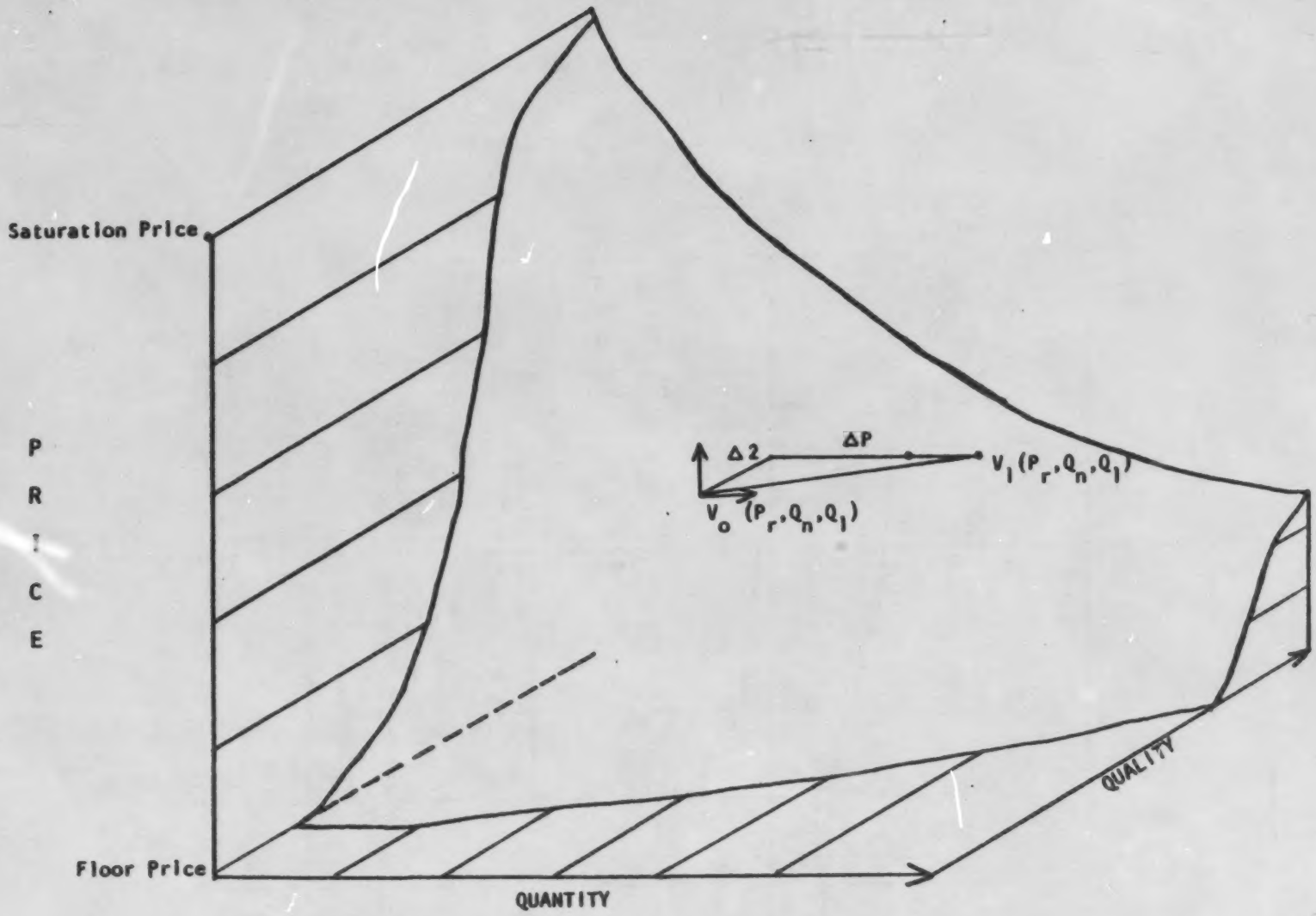


FIGURE 6-2

The Demand-Quality Surface

6-7

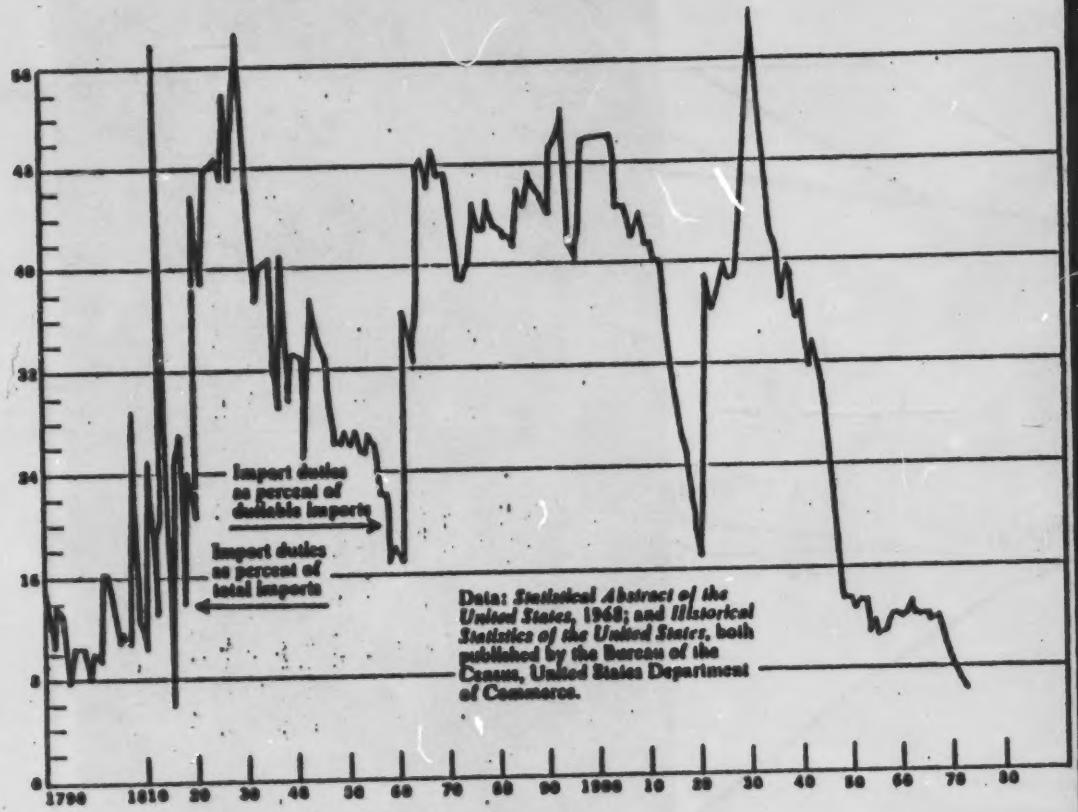


FIGURE 6-3
United States Tariff Rates, 1791 - 1972

/source: Allen, 1971, page 26/

barriers.

This is not to say that the mood for protectionism has entirely disappeared. On the contrary, powerful protectionist interests still exist, although the emphasis has changed from that of an import tariff system to an import quota system or in other forms of nontariff protection, as a means to ameliorating the adverse impacts of effective import competition. One of the methods of protection is, strictly speaking, not protectionist at all. Rather, it is a means of revitalizing import-impacted industries. This is embodied in the Trade Adjustment Act of 1962. The purpose of the Trade Adjustment Act is to provide direct assistance to enterprises and production factors, such as labor unions, which have been absolutely injured by import competition. The intent of the act is to assist these industries or production factors into developing into other areas less subject to import competition. Generally speaking, the present status of US trade policy consists of the minimization of the use of tariffs as an instrument of trade policy, the growth of non-tariff trade barriers as instruments for expressing the success of various protectionist positions, and the corresponding development of means for diverting import-affected, hence presumably less efficient, industries into new areas where they might be more efficient and consequently return to the positive aspects of the law of comparative advantage.

The specific question of relevance to this study is: what roles might personal computer technologies play in this process?

1.1.3 Role of Personal Computers.

The emergence of personal computer technology in the late 1970s provides an opportunity for at least partial redress of the declining US position in technology intensive manufactured products. Specifically, the export of personal computers could augment our export trade in computers for business and scientific purposes (one of the few areas in which our export trade continues to increase). The export of consumer computers could help to counteract our decreasing level of export trade in consumer electronics. Furthermore, sales of personal computers within the US not only will provide an increasing direct source of jobs for US workers but will also partially reduce the import trade in other forms of consumer electronics. This will occur to the extent that consumers decide to purchase personal computers instead of some other form of consumer electronics. All of the above, of course, assumes that personal computers are manufactured in the United States and that the US as a consequence develops a significant comnparative advantage in this particular area of international trade. As is described later, a number of secondary impacts derive from the various potential developments in personal computer technology. These include interrelationships between personal computers and larger computer systems, the semiconductor electronics manufacturing industry, the software industry, and national productivity in general. However, each of these impacts is also influenced by a number of other developments. Consequently, our analysis first deals with the possible direct consequences of the development of the personal computer industry in the US vis-a-vis international trade.

1.2. Alternative Scenarios

The basic consideration in our analysis of the relationships between the development of personal computers and international trade was whether the manufacture of PCs and of related software would be basically dominated by the US. This would require that most of the US market, and a significant portion

of the world market for personal computers, would be supplied by US firms. Alternatively, the possibility exists that the personal computer industry could be a replay of the consumer television equipment industry; that is, the US would initially dominate the market and then, because of a sequence of strategic errors in planning on the part of the industry, lose its world position to import competition. To take the extremes, using our estimates of the market which are provided in Volume 2 of this report, the consumer computer hardware industry sales at the start of the next decade could be as high as $4 billion annually. The business microcomputer hardware industry could be as high as $30 billion annually. Dominance of either of these by foreign competitors would result not only in a displacement of jobs from the US to other countries but also in a proportionate deficit in our international balance of manufacturing trade (the considerations as to what to do about this potential eventuality are discussed in Section 5).

In order to illuminate the present estimates of possibilities of these eventualiites, we prepared a series of questions concerning the personal computer and international trade as part of our overall Delphi surveys discussed earlier. The following are the four scenarios used during our first round study.

SCENARIO A:

Japan, Taiwan, Hong Kong, Korea, Singapore, Mexico and Brazil enter the personal computer market directly, rather than through US firms using offshore production facilities. As in the case of TV sets, these competitors produce a quality product at competitive prices and proceed to capture 30% of the U.S. market in 1982, 50% in 1983, and 80% thereafter. They use the wedge obtained at the PC end of the market to provide a base for actively competing with IBM for the U.S. medium and large size computer market.

SCENARIO B:

The U.S. Government, realizing that personal computers are an industry in which this country has a technological lead, takes steps to protect the industry. These steps include:

1. R&D support to microprocessor manufacturers, development firms and software houses.

2. SBA aid to personal computer firms.

3. Initiating a program to buy PCs for school use following a Federally sponsored development of educational software.

4. Mass installation of PCs in Federal offices to increase government productivity (see Workforce Scenario).

5. Clear signals to foreign countries that domestic PC markets will be protected through tariffs and non-tariff barriers.

SCENARIO C:

The Japanese and the British invade the personal computer market in force. The Japanese, using their strength in semiconductors and in consumer products, expand from using microcomputer chips in special purpose appliances to building stand-alone PCs (including conversion of surplus, US directed color TV sets to PCs). By providing PC/TVs they circumvent US import restrictions on TVs. They market through their TV, high fidelity, and other existing distribution chains. The British, following up on their decision

that they will develop semiconductor technology, choose microcomputers as a market for this technology. They develop PCs and, with their programming skills, develop excellent software to go with it. The British market their product worldwide.

The U.S. government takes a free-trading stance, since it wants to encourage the British to advance their technology, even though this means Japanese encroachment as well.

SCENARIO D:

The French, building on their development of a low cost, combined telephone and computer terminal, including video display, form joint ventures with U.S. firms to develop a network information systems/personal compter market. Other European countries and Japan, seeing this as a major threat to their own plans in the telecommunications/computer market, engage in intense, government- subsidized price cutting to compete.

The U.S. government, with no established position for such an eventuality, fails to develop a coordinated, coherent policy. The U.S. domestic industrial position in telecommunications and computers is significantly eroded.

AN UNDERLYING SCENARIO

The four scenarios just presented are all variants on a more fundamental one which evolved during the writing of the Delphi scenarios. This underlying scenario arose from an examination of broader trends in contemporary U.S. industrial development. These trends are the subject of much of the following analysis. The underlying scenario is called "The Doomsday Scenario" (Figure 6-4) because of its gloomy view of the prospects for U.S. international competitiveness if the nation continues to pursue current policies and practices. Unfortunately, as in the other areas of impact assessment, there is very little in the way of hard data to support claims concerning the likelihood of this scenario for the case of personal computers. Nevertheless, examination of the scenario and its impacts allows us to point up relevant policy considerations.

2. Impacts of the Technology

2.1 Economic

The economic impacts of personal computer technology vis-a-vis international trade fall into two natural categories: the effects due to import and to export trade. First, we will examine these effects under assumed free trade conditions.

2.1.1 Direct Effects

At present, US manufacturers ship about 35% of their mainframe and minicomputers to other countries. (International Data Corporation, 1979) 65% of all mainframe and minicomputers manufactured by US firms are used within the United States. For the sake of argument, let us assume that these ratios are a gauge of the information industry intensiveness of the world, but that the distribution between personal computers used in the United States and in other countries will be slightly different. That is, 80% of all consumer computers produced and all educational system PCs will be used within the United States, while 50% of the business and scientific PCs produced will be shipped abroad. The estimates we have made for personal computer sales, in

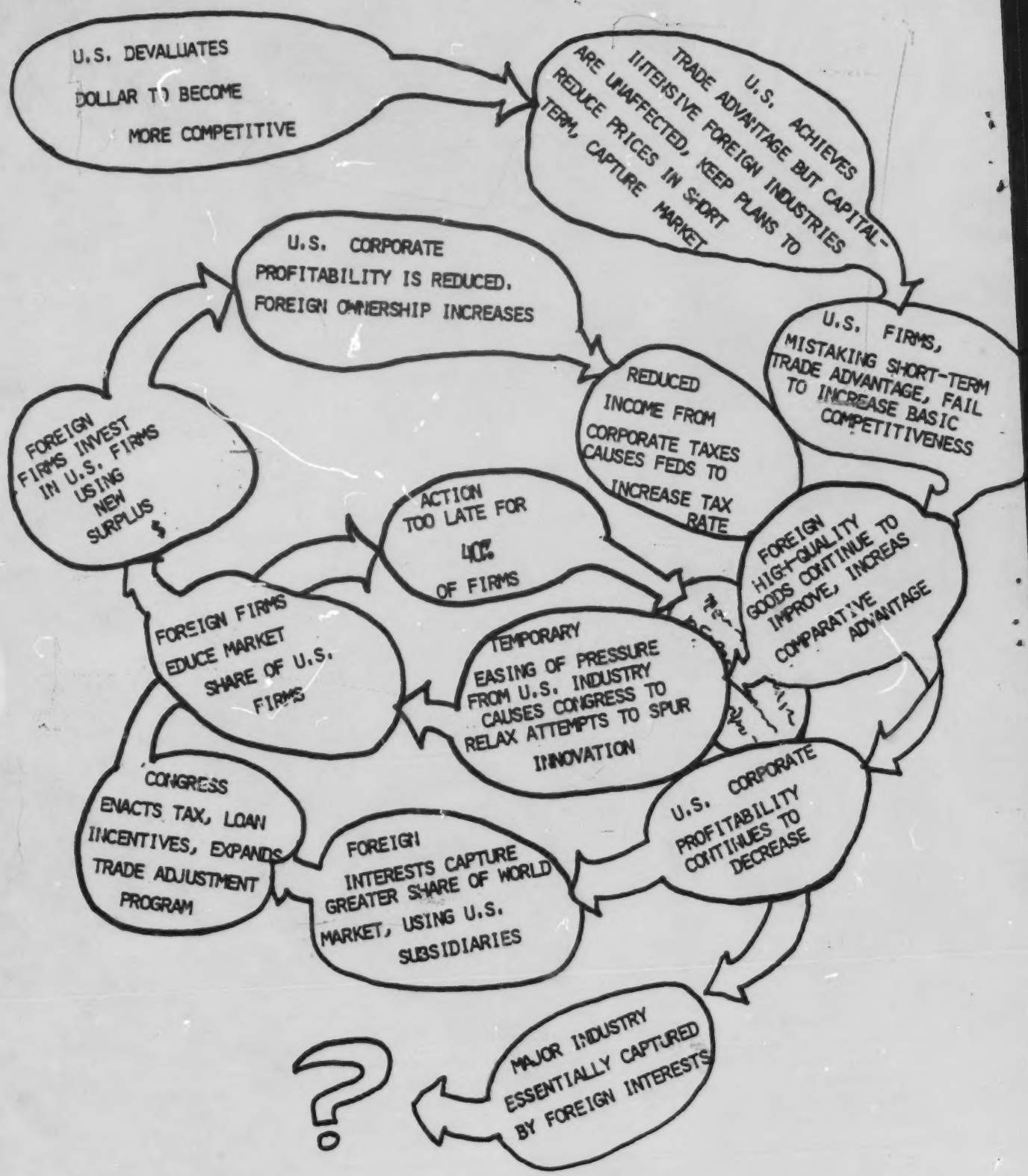

U.S. DEVALUATES DOLLAR TO BECOME MORE COMPETITIVE
U.S. ACHIEVES TRADE ADVANTAGE BUT CAPITAL-INTENSIVE FOREIGN INDUSTRIES ARE UNAFFECTED, KEEP PLANS TO REDUCE PRICES IN SHORT TERM, CAPTURE MARKET
U.S. CORPORATE PROFITABILITY IS REDUCED, FOREIGN OWNERSHIP INCREASES
U.S. FIRMS, MISTAKING SHORT-TERM TRADE ADVANTAGE, FAIL TO INCREASE BASIC COMPETITIVENESS
REDUCED INCOME FROM CORPORATE TAXES CAUSES FEDS TO INCREASE TAX RATE
FOREIGN FIRMS INVEST IN U.S. FIRMS USING NEW SURPLUS $
ACTION TOO LATE FOR 40% OF FIRMS
FOREIGN HIGH-QUALITY GOODS CONTINUE TO IMPROVE, INCREAS COMPARATIVE ADVANTAGE
FOREIGN FIRMS EDUCE MARKET SHARE OF U.S. FIRMS
TEMPORARY EASING OF PRESSURE FROM U.S. INDUSTRY CAUSES CONGRESS TO RELAX ATTEMPTS TO SPUR INNOVATION
CONGRESS ENACTS TAX, LOAN INCENTIVES, EXPANDS TRADE ADJUSTMENT PROGRAM
FOREIGN INTERESTS CAPTURE GREATER SHARE OF WORLD MARKET, USING U.S. SUBSIDIARIES
U.S. CORPORATE PROFITABILITY CONTINUES TO DECREASE
?
MAJOR INDUSTRY ESSENTIALLY CAPTURED BY FOREIGN INTERESTS

FIGURE 6-4

THE DOOMSDAY SCENARIO: THE INTERNATIONAL TRADE SPIRAL

Volume 2 of this report, can then be modified to show potential world sales of personal computers over a similar period. Obviously, this argument is too simplistic since the ratio of US to rest- of- world computer sales is affected by a number of factors, including rate of industrialization, sociological considerations, average level of education, relative growth rates of information industries, and the like. However, the purpose here is not to provide definite predictions but to indicate rough orders of magnitude of potential import/export trade. These estimates are shown in Table 6-3. The table includes estimates of related software trade based on conversations between J.M. Nilles and various members of industry and user communities. There are no disaggregated software sales data available from public sources known to the author.

The extreme positions regarding international trade in personal computer technology are these:

* The United States completely dominates the international market as well as the national market for personal computers, maintaining a monopoly position in the production of both personal computer hardware and software. This would result in the development of a national market in 1990 of from $6 billion to $23 billion and an international market of from $4 billion to $18 billion, all of which would appear on the positive side of our international balance of payments.

* The US loses the personal computer industry in its entirety, due to completely effective import competition. Under free market conditions, and assuming no buyer sentiment resulting in a "buy American" attitude, the US would experience a direct deficit in the international balance of merchandise trade of from $6 billion to $23 billion in 1990. It would also, of course, incur an international trade opportunity cost of from $4 billion to $18 billion, although this amount would not show up in the international chart of accounts.

* The opinion of our Delphi panelists was that US firms would account for about 80% of the domestic personal computer market and about half of the market in the rest of the world, based on certain assumptions concerning both the rates of growth in size and quality of the US personal computer hardware and software industries and on specific sets of Federal policies to be discussed later. If these estimates were to be realized then the direct effect on the US international balance of trade in 1990 would be to contribute from $6 billion to $23 billion to a positive US balance.

2.1.2 Indirect Effects

There are also potential secondary effects associated with these various international trade scenarios. For example, the manufacture and use of personal computers can involve several aspects of international trade to the extent that components of the personal computers themselves are manufactured outside (or inside) the United States, or that related materials, such as paper for printouts, plastics and coatings for magnetic storage media, associated furniture and cabinetry, etc., are manufactured or supplied internationally. At this stage, it is impossible to estimate accurately the magnitude of these secondary items of the trade flow. Porat estimates the magnitude of this effect as about 120% of the value of the direct computer

TABLE 6-3

Estimated[1] Potential 1990 Personal Computer Market

TYPE OF APPLICATION	US SALES ($B)[2]	REST OF WORLD SALES ($B)[2]	TOTAL SALES ($B)[2]
EDUCATION			
Hardware	0.1 to 0.3	0 to 0.1	0.1 to 0.4
Software[3] (@40% of HW)	0 to 0.1	0 to 0	0 to 0.1
BUSINESS			
Hardware	3.8 to 15.2	3.8 to 15.2	7.6 to 30.4
Software[3] (@20% of HW in US, @10% of HW, ROW)	0.8 to 3.0	0.4 to 1.5	1.2 to 4.5
CONSUMER			
Hardware	1.2 to 3.3	0.2 to 0.7	1.4 to 4.0
Software[3] (@30% of HW in US, @20% of HW, ROW)	0.4 to 1.0	0.1 to 0.2	0.5 to 1.2
TOTAL	6.3 to 22.9	4.5 to 17.7	10.8 to 40.6

1 NOTE: These are rough estimates only, to be taken CUM GRANO SALIS.

2 Constant, 1980 Dollars.

3 Software sales estimates are confined to sales where the user interface is in English.

cost. That is, the total effect on the economy of the low estimate of $10 billion in annual sales of PCs manufactured in the US would be about $22 billion. However, it is impossible to verify these estimates given the changes in technology and economic environment which have occurred since Porat's work.

One interesting secondary impact of personal computer technology relates to the consequences of the use of personal computers within the United States upon US worker productivity and, consequently, upon the comparative advantage of the United States in various other industries. To the extent that personal computers actually improve worker productivity there should be a proportionate, if not linear, effect on our international trade position. Even greater leverage may be experienced as a consequence of the potential ability of personal computers to greatly accelerate the growth of new forms of information industries involving international information services of various sorts (search services, information storage and retrieval, electronic message systems, electronic funds transfer, specialized programming services, etc.).

On the other hand, the availability of international telecommunications networks and low-cost personal computers may make a flow in the other direction easier, allowing countries with low labor costs to capture routine data processing services, via personal computers and satellite telecommunications, which would otherwise be performed by US workers. In this instance, the "transportation" cost component which normally affects the magnitude of trade in manufactured goods, is significantly reduced by low telecommunications costs, possibly making them almost invisible. Aside from the cost issue, there may be process advantages in trans-shipping routine information processing work (see, for example, Nilles, 1978). The basic principle here is that an organization anywhere in the world can ship its end-of-the-business-day information work to more westerly time zones for completion and transmittal back to the point of origination prior to the start of the next day's business, thereby accelerating the pace, if not the accuracy or utility, of information processing.

The effect of these international personal computer trade-related possibilities on jobs within the United States can be estimated basically as some factor proportionate to the magnitude of the various forms of trade themselves, although some delays in timing may occur. In general, workers in both the primary and secondary information industries receive higher wages than those in other sectors of the US economy. Consequently, the number of workers affected by a unit dollar change in international trade is correspondingly lower than the number of workers affected by a change in some other sector.

2.2 Sociological Impacts

The export of personal computers and, particularly, personal computer software, by the United States to other countries may constitute an important, if subtle, means of cultural exchange. The same is of course true for transfer in the reverse direction. As has already been commented on by numerous authors, the introduction of computers in developed nations has had the effect of spreading organizational technologies more uniformly throughout these nations as a consequence of their embodiment in the operating systems and applications software. Like the mass media, exchange of software for consumer computers has effects in altering both perceptions of the originating culture and the aspirations and expectations of the user of the software. For example, consider the development of a "pop" software market in which the latest "hit" program, possibly incorporating biofeedback routines, becomes an overnight international success. The effect on increasing cultural

homogeneity would presumably be at least comparable to that of a similar best selling popular recording.

As English has rapidly become one of the standard and dominant international languages, a similar destiny may be in store for the common computer higher level languages, although the spread may be more limited at first to the science, technology, and business communities. Like the effect of the personal computer within the United States, the international effect of this additional means of cultural transfer would surely be proportional to the number of computers in use.

About all that can be said with accuracy at this stage of development of personal computer technology is that the international sociological effects of the use of personalcomputers may be quite profound. It is conceivable that the magnitude of their impact may be in direct proportion to the pre-PC level of technological ignorance of the recipient country. Thus, the distribution of a relatively small number of personal computers in developing countries could have considerably greater impact on increasing the rate of economic development of the country, through transfer of improved organizational technologies embodied in the computer software, than the same level of distribution in a sophisticated country such as one of the members of the EEC or Japan.

2.3 Political Impacts

The primary political impact of potential trends in the development of international trade in personal computers is likely to appear in the form of pressure from representatives of the personal computer industry should the United States begin to lose a substantial portion of its international market position in personal computers. The semiconductor industry has already shown itself to be quite capable of raising vociferous cries of alarm in response to perceived threats of competition from Japan. The personal computer industry does not yet have its own association or lobbying action group, except to the extent to which it works through the Electronic Industries Association. Nor are manufacturers or distributors of personal computers at present particularly concerned about import competition since they are either totally involved with establishing a domestic business or have already captured a substantial portion of the export market in Europe or Japan. Demand, both nationally and internationally, appears to be well ahead of supply at this juncture.

Since the members of the personal computer industry, like those in the semiconductor industry, tend to be relatively sophisticated individuals, it is likely that pressures for political action in the case of real or apparent weakening of the US position in the international market will be concentrated on legislation to provide economic incentives in the form of loan guarantees, R&D subsidies, tax incentives, relaxation of antitrust regulations, and the like, rather than for protectionist actions such as imposition of tariffs or import quotas.

3. Self-Organizing Responses

3.1. Private Sector.

The personal computer industry, as of this writing, appears to be emulating the semiconductor and larger computer industries in its response to the opportunities and hazards of foreign trade. Those firms which have reached a level of success to put them in the medium-sized business category all appear to be developing vigorous export sales activities. Even some of

the smaller firms, with dozens instead of hundreds of employees, are exporting personal computers and PC components. One of the firms specializing in personal computers for business and industrial applications expects to have 60% of its gross sales in export trade by 1982 (as compared with slightly more than one-third of gross sales to exports among US-based mini and mainframe computer firms). Although Japanese (Sharp) and Swedish (Scandia Metric) personal computers are selling in Europe, preliminary sales reports indicate that American-made personal computers are outselling these competitors by at least a factor of ten. In short, as of the end of the first quarter, 1980, the immediate prospect is quite positive that the personal computer industry will provide a positive component of the international balance of manufacturing trade. The first Japanese manufactured PC (probably one made by NEC) will likely not be introduced to the US market until mid- to late 1980.

However, the issues to be discussed here concern the longer term prospects for the industry. Since the personal computer industry is quite new, still in its infancy, we cannot draw on any historical evidence but must instead depend on analogous historical developments and test these to see whether the salient determinants of progress or failure of the industry are similar.

The three industries most closely allied to the personal computer industry are semiconductors, larger computers, and television. The semiconductor industry provides the key elements of production of the personal computer industry: the microelectronic chips. Consequently, the rate of development and success of the semiconductor industry, both within the United States and in foreign countries, will closely affect the rate of development of the personal computer industry. The business uses of personal computers will follow trends analogous to the development of the minicomputer industry. In fact, the business PC and minicomputer industries will merge as 16 bit microprocessors become generally used. Finally, the consumer computer portion of the PC industry is analogous in many respects to the TV industry.

It is clear that several foreign countries have vigorous plans to compete with the United States in both the semiconductor and computer industries. Competition from other countries, notably Japan, has already had major and detrimental effects on the US television and CB radio industries. Since the ultimate policy responses to these technologies are likely to be the same or similar, it is in order at this point to briefly review the history of the US semiconductor, computer, and television industries vis-a-vis international trade.

3.1.1 Semiconductor Industry - US Developments

The US semiconductor industry is about twenty years old, about two-thirds the age of the US computer industry. It is one of the most productive of US industries; its productivity is estimated to have increased by a factor of 20,000 during the existence of the industry. The world market for various types of semiconductor products quadrupled during the 1970s and is expected to grow at an annual rate of almost 15% during the 1980s. Anticipated sales of the industry in 1990 are $60 billion (as compared with annual sales of $13 billion in 1979).(Noyce, 1980; Business Week, 1979) Almost all the innovations in the semiconductor industry; have been made by Americans. In 1976, US firms had about a 71% share of the world market in semiconductors, with 21% of the market supplied by Japan. Estimates for 1980 are 64% and 25%, respectively (Nora and Minc, 1978).

Robert Noyce, Vice Chairman of INTEL Corporation, gives a brief history of the growth of his company.

> Within one year after my company was founded — twelve years ago — we opened a European sales office. Within two years we established our initial marketing outlet in Japan. International sales have risen from less than 25% of total sales by US semiconductor companies ten years ago to over 35% today, reflecting the extremely rapid growth rates of demand for our products in the European Economic Community and Japan, coupled with aggressive international marketing efforts by the American companies.
>
> This internationalization has extended beyond exports as the US semiconductor companies constructed foreign plants, principally in the Far East and Europe. To capitalize on marketing opportunities and to avoid the high EEC tariffs, US companies make direct investments in modern-point-of-sale factories in Europe. Rather than a substitute for exports, these factories have produced a leveraging effect on US exports, acting as a local outlet to 'pull through' increased shipments of products manufactured in the United States. [emphasis added]....The international efforts of the US semiconductor industry have benefitted the US economy even though some of our production steps have been conducted offshore. An estimated 80% of total value added in American semiconductors has remained within the United States, enabling the United States industry to preserve its domestic market share, while substantially increasing sales abroad....The tendency appears to be a decrease of foreign employees as a percent of total employees. This trend is enhanced by the increased use of automatic bonding equipment in the offshore assembly plants. INTEL, for instance, more than tripled total corporate employment from 1975 to 1979, but the proportion of foreign employees dropped from a peak of 41% in 1976 to 30% in 1979, even though a higher percentage of sales were abroad and a higher percentage of our total employees were foreign sales and marketing personnel.
>
> ....INTEL Corporations's foreign sales in 1979 were $100 million more than its overseas expenditures in that year. For the five years ending December 31, 1979, INTEL contributed a cumulative surplus of $286 million to the US balance of payment as a consequence of its worldwide operations...I understand from SIA staff that other SIA members have a similar experience (Semiconductor Industry Association, Noyce, 1980).

To recap the key points made by Noyce, the US semiconductor industry has 1) dominated the world semiconductor market; 2) made significant and growing direct contributions to the positive side of the US international trade account; 3) made indirect contributions to our balance of payments by virtue of related US export leveraging effects; and 4) retained a large share of the international trade benefits, in both income and employment, within the United States.

3.1.2 Semiconductor Industry - Foreign Responses

Although the US semiconductor industry is clearly the major innovator and sharer in the international market, competition from other developed countries, notably Japan, is developing and becoming increasingly more vigorous. The view point of the leading US semiconductor industrialists, as expressed by the Semiconductor Industry Association before Congress, is that the Japanese threat is substantial and that a major reason for the rapid increase in magnitude of the threat is a significant amount of intervention in

the development process by the Japanese government. A particular sore point with the Semiconductor Industry Association is the increasing cost of capital equipment of the industry together with the gross differences between the United States and Japan in the availability and cost of financing for that equipment. Specifically, according to the Morgan Stanley Electronics letter dated September 14, 1979 (see Table 6-4), the capital investment in plant equipment, as measured in percent of annual sales, has grown by 60%. This increased rate of investment in capital equipment will probably continue in the foreseeable future as the demands of increasingly intense microminiaturization require correspondingly more sophisticated production equipment. Funds for this investment must come from substantial reinvestment of profit, increased debt, or increased provision of equity from external sources. The Noyce/SIA analysis of the present situation is as follows:

> 1979 US IC sales worldwide were $4.6 billion. My basic assumptions are that:
>
> — the IC market will continue to grow in the 1980s as it did in the past decade at an average annual rate of 22%, compounded (although growth of nearly 42% occurred in 1979);
>
> — the US will retain its 60% share of the world market;
>
> — annual asset turnover (sales divided by total assets) will decline from 1.5 to 1.0 dum to increasing equipment costs; and
>
> — the average debt-to-equity ratio of the semiconductor industry will increase from its present 15:85 to the US industry-wide average of 25:75.
>
> With projected cumulative sales for the ten years ending December 31, 1979 of $206.4 billion, annual sales of ICs by American producers should rise to $41 billion by 1990, which would be nine times our 1979 sales volume. Given the increasing capital intensity in our industry, under the foregoing assumptions we can achieve this sales growth in the decade ahead only by making a cumulative investment in IC plant and equipment of approximately $28 billion.
>
> If no new equity is raised by the US industry and with a debt/equity ratio of 25:75, the US semicondicutor industry will have to increase after tax earnings to 13.5% of sales to finance capital requirements. Please bear in mind that a return of 13.5% is over three times the average US semiconductor earnings on 4.3% of sales during the period 1968-77, as reported in the Department of Commerce.

The requirement for increased research and development expenditure is similar, according to Noyce. The semiconductor industry owes its position of prominence to a relatively high rate of invesment in research and development. A substantial initial fraction of that investment was made by the US government, as will be discussed later.

Foreign industries and governments, again notably Japan and members of the European Economic Community, currently have, or are trying to develop, respectively, substantial indigenous R&D programs in the microelectronics area, notably in the field of VLSI (very large scale integration). The key issue is not whether these various participants in international competition are relatively more or less capable of competing, by virtue of some inherently

SEMICONDUCTOR CAPITAL EXPENDITURES AS % OF SALES

COMPANY	1976	1977	1978	1979E
TEXAS INSTRUMENTS	9	12	12	14
INTEL	22	23	35	30
MOTOROLA	9	9	10	13
NATIONAL SEMICONDUCTOR	13	11	12	14
FAIRCHILD CAMERA	9	6	6	12
SIGNETICS	6	10	18	22
ADVANCED MICRO DEVICES	11	8	16	22
MOSTEK	17	28	14	16
INTERSIL	8	4	9	17
AMERICAN MICROSYSTEMS	4	5	8	11
TOTAL	10	11	13	16

Source: Morgan Stanley Electronics Letter September 14, 1979

TABLE 6-4

greater or lesser ability to come up with innovative ideas, but rather of the relative differences in other determinants of competitiveness, such as availability of investment capital to the prospective competitors.

The total government expenditures for development of semiconductor products in the rest of the world are about $2 billion, according to Rockwell International (see Table 6-5). Finally, a recently popular mode of gaining US semiconductor know-how has been through the acquisition of a controlling interest in a US firm. Table 6-6 shows the ownership of the top 20 US semiconductor firms. Eight of them have been acquired by foreign interests, generally, as seen from the acquiree's point of view, as a means of obtaining necessary capital for expansion.

3.1.3 US Computer Industry.

Similar comments can be made about the US computer industry. In 1977, the worldwide data processing revenue of US computer companies accounted for 85.6% of the world total, with Japan running second with 7.3% of the world market. In fact, revenues to IBM alone accounted for 48% of the world market in 1977, according to an A. D. Little survey (Rothenbuecher, 1978). The largest European competitor in the computer field is CII of France which has extensive technology sharing agreements with Honeywell, the seventh ranking US company.

The United States has about 46% of the world's 200,000 large computer systems, with Japan next at about 22%. Japan, with a gross domestic product which is about one-third the size of the United States', thus has about half as many computers as the United States. While IBM has at least half of the mainframe computer market in most of the developed countries of Western Europe, it only accounts for about 25% of the market in Japan. (World Business Weekly, 1979)

In the United States, almost the entirety of US computer installations is supplied by US firms (neglecting the issue of foreign investment in US firms to be discussed later). Hence, there is no question that US computer firms dominate not only the domestic but the world market as well. However, that domination is being reduced by increasing levels and sophistication of competition from other countries.

3.1.4. Foreign Responses to the US Computer Industry

In 1972, the Japanese government published a white paper in which it stated as a matter of national policy that Japan would concentrate on equalling or surpassing the United States in the production and distribution of computers. Table 6-7 shows the effects of this policy. This table clearly shows the rapid growth in Japanese export trade in computers, although "a significant amount of the domestic production is supplied by foreign firms manufacturing locally." The effects of Japanese concentration on development of their computer industry in competition with the United States is more graphically shown in Table 6-8. Here it is seen that over a four year period Japanese computer and related equipment exports have increased by a factor of thirteen, while US exports to Japan have only gone up by 68%.

In Europe, the situation is somewhat different. The US share in the Western European market for large computers has remained about constant since the mid-70s at about 80% (including the contribution by CII-Honeywell Bull). Two Western European firms, International Computers Ltd. and Siemens of Germany, account for about one-sixth of the Western European market for large computers. In the growing field of mini computers, however, the US share is just over half, led by Digital Equipment Corporation with about one-fifth of

TABLE 6-5

COMMERCIAL GOVERNMENT SUBSIDIES AND LOANS FOR SEMICONDUCTORS

PROPOSED & ACTUALS

COUNTRY	MAIN RECIPIENT	STATE FUNDS ($M)
GERMANY	VLSI DEVELOPMENT	100 (30-40 YEARLY)
ITALY	SGS-ATES, et al	135
FRANCE	ST. GOBAIN PONT A MOUSSON	50
	MINISTRY OF INDUSTRY TO THOMPSON CSF-SSC	120 TO 200
	THOMPSON CSF + CEA (SESCOSEM/EFCIS)	
	RADIOTECHNIQUE COMPELEC	25
	MATRA	38
UK	UK TOTAL: $330M	
	NEB AVAILABLE FUNDS LIMIT: $6B	
	NEB TO INSAC (SOFTWARE CONSORTIUM)	40
	NEB TO INMOS LTD.	20
	NEB TO PLESSEY (LOAN)	40
	DOI TO MISP (MICROELECTRONIC INDUSTRY SUPPORT PROGRAMME)	140
	DOI TO MAP (μP APPLICATIONS PROJECT)	110
	E-BEAM FAB TECHNIQUES	1.8
	NCC — AWARENESS PROGRAM (SOFTWARE TRNG)	20
JAPAN	VLSI SUBSIDY (LOAN)	250
KOREA	TOTAL PROJECTED LOAN & SUBSIDIES	600
	GOLD STAR	20
	KIET — WORLD BANK LOAN	29
TOTAL GOVERNMENT EXPENDITURES WORLDWIDE FOR PROMOTING SEMICONDUCTORS		~ 2.0B

Source: "Impact of Semiconductor Nationalism on American Trade, Technology and Defense," Terry Wong, Rockwell International, April 1979.

TABLE 6-6

Acquisitions of U.S. Semiconductor Firms

Est. 1979 I.C.

		SALES ($ Million)	
1.	TI Semiconductors	$680	Div. of TI, Inc.
2.	Motorola Semiconductors	425	Div. of Motorola, Inc.
3.	Intel	400	---
4.	National Semiconductor	320	---
5.	Fairchild	305	acquired by Schlumberger (France)
6.	Signetics	250	acquired by N.V. Philips (Netherlands)
7.	Advanced Micro Devices	160	owned by Siemens (W. Germany)
8.	MOSTEK	155	acquired by United Technologies
9.	RCA Semiconductors	145	Div. of RCA
10.	Harris	100	Div. of Harris Corp.
11.	American Microsystems	95	acquired by Robert Bosch Gmbl (W.Germa
12.	Rockwell Semi	85	Div. of Rockwell International
13.	General Instrument	80	Div. of G.I., Inc.
14.	Intersil	75	acquired by Northern Telecom (Canada)
15.	Synertek	50	acquired by Honeywell
16.	Analog Devices	40	acquired by Standard Oil
17.	Monolithic Memories	35	acquired by Northern Telecom
18.	Siliconix	30	acquired by Lucas (Great Britain)
19.	Solid State Scientific	22	acquired by Adolf Schindling (W.German
20.	Zilog	15	acquired by EXXON

/Source: Datamation, April 1980/

TABLE 6-7

Japan's Market for
Computers and Related Equipment
(excluding parts)

(millions)

	1974	1975	1976	1977	1978
Production in Japan	$2,020.6	$1,823.6	$2,087.0	$2,678.5	$4,324.6
Exports	83.2	107.7	132.5	152.7	331.1
Imports	398.6	323.9	319.5	408.1	391.3
Consumption	2,336.0	2,039.8	2,274.0	2,933.9	4,384.8
Production as % of consumption	86.5%	89.4%	91.8%	91.3$	98.6%

Note: Yen/dollar conversions made from International Financial Statistics, International Monetary Fund, Japan table, line af.

Source: The computer production figures, 1974-76, are from the Computer White Paper, 1977 Edition, published by the Japan Information Processing Center, p. 14. The production figure for 1977 is from the Current State and Progress of The Computer Industry in Japan, 1978, Japan Electronics Industry Association, p. 3. The 1978 production figure was taken from an article appearing in Electronics News, April 24, 1978. The import and export figures are from year-end volumes of Japan Exports and Imports-Commodity by Country, published by the Japan Tariff Association.

/Government Accounting Office, 1979/

TABLE 6-8

Bilateral Trade in Computers and Related Equipment
(including parts)

	1974	1975	1976	1977	1978
U.S. Exports to Japan	$281.7	$214.1	$271.7	$346.2	$367.9
Japanese Exports to U.S.	16.7	33.5	99.7	96.9	218.1
Balance	265.0	180.6	172.0	249.3	149.8

NOTE: Yen/dollar conversion handled as in Table 6-7

/source: General Accounting Office, 1979/

the European market. (European Trade Union, 1979) In general, the response of European computer industry to date has been one of reacting to the lead taken by US firms rather than the Japanese attitude of trying to wrest the lead from the United States. This attitude is reflected in (or reflects) the attitudes of the respective governments of these competitors, as will be seen.

3.1.5 The US TV Manufacturing Industry

The US TV manufacturing industry provides a prime example of our scenario for takeover of a US developed industry by foreign competition. The report of the US Comptroller General neatly summarizes the history:

> The issue of US imports of color television receivers (CTRs) from Japan is critical because of the scale of the bilateral imbalance and the fact that in 1968-78, some 60,000 US jobs in television manufacturing have been eliminated. Simultaneously, imports of US TV sets produced overseas increased from 20 percent in 1970 to 70 percent in 1975, as more and more US producers shut down their US production facilities and began producing in Taiwan, Korea, and Mexico.
>
> US CTR manufacturers contend that much of the success of the Japanese in the US market has been due to their violations of US trade laws and international trade agreements. Domestic producers further complain that Japanese producers have free and open access to US markets, while US manufacturers are prevented form entering the Japanese market by a myriad of NTBs [non-trade barriers]. On the other hand, Japanese producers contend that because US products are inferior in quality and performance, they do not sell well in the Japanese market, and that US manufacturers have not tried hard enough to sell them.(Comptroller General, 1979)

It is clear that there have been significant levels of interference by the Japanese government in the devlopment of US exports to Japan. These will be discussed in the next section. However, it is also clear that there is some truth to the claims by the Japaneseindustry that US manufacturers have not been responsive to the market opportunities available to them. In reviewing the US corporate sins of omission in this regard, the GAO concluded:

> The deleterious effect of miscalculations in corporate policy is gaining more acceptance as a significant factor affecting US sales of CTRs. Essentially, the story is one in which US manufacturers 'missed the boat,' not only in the case of CTRs, but also in the earlier cases of monochrome TVs, stereo equipment, and transistor radios.

In the case of CTRs, according to one of the major proponents of the theory (Ableggen and Rapp, 1972) initial Japanese average wholesale prices in 1962 were high compared to US prices ($500 vs. $350 a set), and Japanese sets were smaller. However, due to extraordinary growth in demand in Japan after 1965 and the subsequent dramatic increases in production, costs and prices rapidly declined. Production grew from 98,000 units in 1965 to 6.4 million units in 1970 — a 196 percent per annum growth compared ot a 41 percent growth rate for the United States — with only 16 percent of this production being exported.

During this period, according to the theory, the rapidly growing Japanese market was relatively unprotecterd as compared with textiles, steel,

or autos. Primarily because the Japanese government never considered consumer electronics a strategic or important industry, its development did not depend on marketing restrictions, high tariff barriers, and other protective measures. Thus, there was little to prevent US exports and market penetration when the United States was the world's low-cost producer. Furthermore, with a lack of competition from the United States, Japanese producers were able to take advantage of a phenomenal growth in demand to produce in great volume. As a result of this volume production, costs and thus prices were significantly reduced, making the Japanese the most formidable of international competitors at the expense of a previously more experienced and competitive US industry.

3.1.6. The TV Manufacturing Industry - Foreign Responses

As was evident in the previous paragraphs, foreign firms, mostly Japanese, have been quite successful in the past in penetrating the US TV market. Their success at present would undoubtedly be even higher were it not for the success of protectionist activities on the part of the US television industry which resulted in an orderly marketing agreement (OMA) between the United States and Japan in 1976, effective for the three years beginning July 1, 1977. This OMA limits exports by Japan of color TV sets and subassemblies to the United States. However, this did not solve the problem. Imports from Taiwan and Korea immediately began to fill the gap left by the drastically reduced Japanese imports, until similar OMAs were negotiated with those two countries in December 1978. Figures 6-5 and 6-6 summarize the events.

Japanese firms further reacted to the import restrictions by investing in US subsidiaries, to the point where in 1977, one-sixth of US TV production (and of employment of Americans in the TV industry) was by the US subsidiaries of Japanese firms. Interestingly, it appears that the complex aspects of TV set production are still performed in Japan, with the more routine (i.e, automateable) jobs being performed by US workers. In recent years the level of Japanese involvement in the US-based television production has increased, although accurate figures were not available at the time of writing of this report.

3.2. Public Sector Responses

3.2.1 US Government Actions

Until very recently, the most accurate statement one could make about US foreign trade policy was that there was no coherent, comprehensive, integrated policy. Throughout the history of the United States, most of its trade was entirely internal. We have been blessed with abundance of resources and ample room for internal growth. As a consequence, there has been very little pressure for the export of US products overseas. The average US businessperson rarely thinks in terms of export sales, unlike the businessperson in Europe or Japan. Where we have exported goods in the past, it has been in areas where we have had a clear and significant comparative advantage, generally due to either a control of scarce resources or definite technological superiority. Because of this set of conditions, international trade was never given very high priority by the Federal government. Responsibility for various aspects of international trade was scattered among a dozen departments and agencies within the government, many with overlapping or ill-defined jurisdictions and responsibilities. This situation has been in startling contrast to that of the countries of Western Europe and Japan, in which both business attitudes and government functions are strongly oriented

FIGURE 6-5

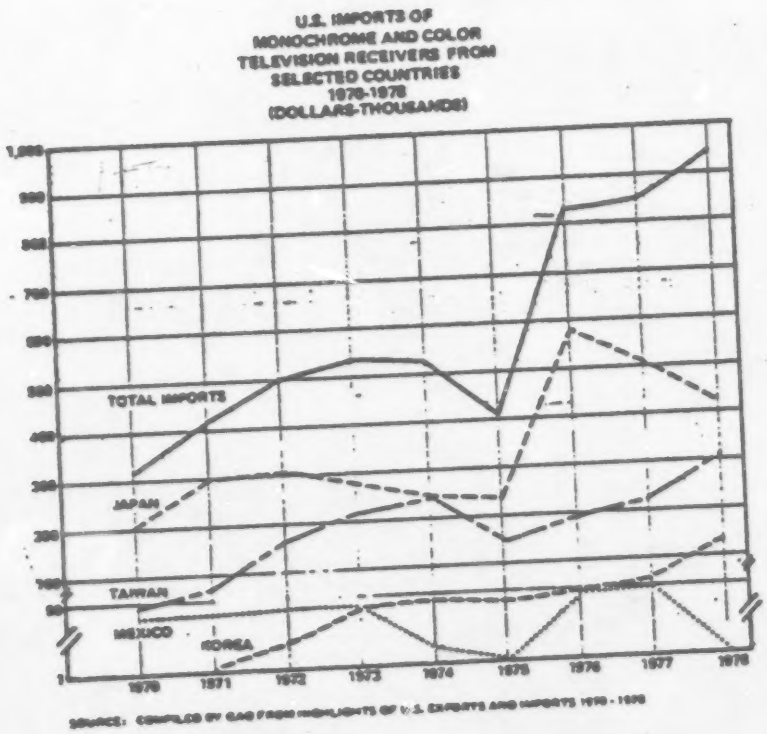
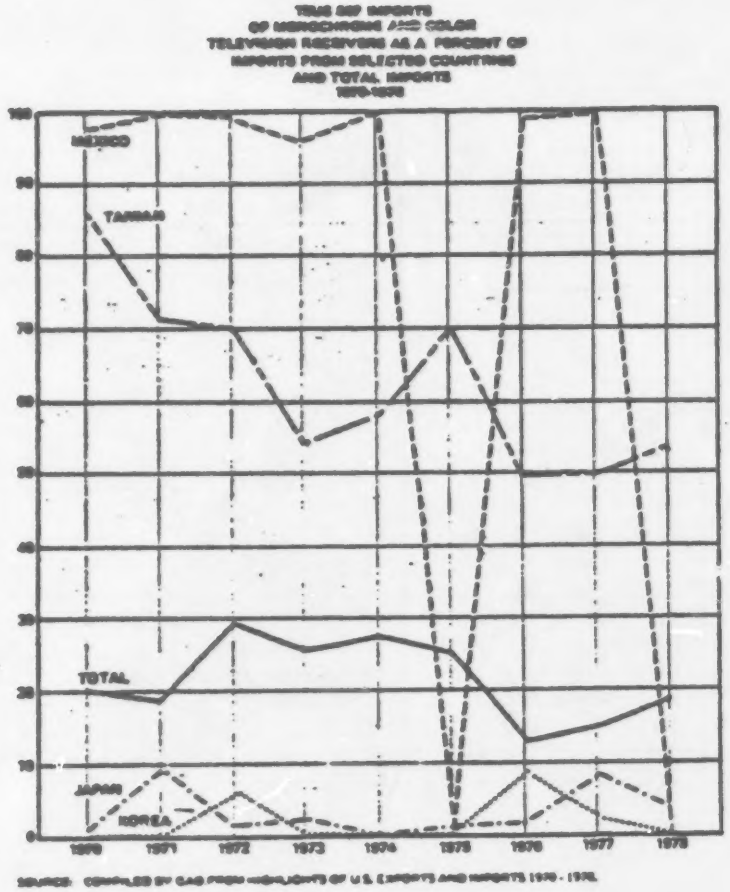

U.S. IMPORTS OF
MONOCHROME AND COLOR
TELEVISION RECEIVERS FROM
SELECTED COUNTRIES
1970-1978
(DOLLARS-THOUSANDS)
TOTAL IMPORTS
JAPAN
TAIWAN
MEXICO
KOREA
1970
1971
1972
1973
1974
1975
1976
1977
1978

FIGURE 6-6


MEXICO
TAIWAN
TOTAL
JAPAN
KOREA
1970
1971
1972
1973
1974
1975
1976
1977
1978

toward export trade, as will be seen in section 2.2.2.

As was mentioned in Section 1, with the continuing decline in the US balance of merchandise trade, together with repeated warnings by analysts such as Boretsky, it became clear to many within Congress and government that the United States could no longer afford to neglect the development of a vigorous international trade policy. As an example,

> In 1960 exports of goods and services constituted less than 4% of the GNP of the United States. By 1978 they constituted 9%. Imports of goods and services amounted to 3% of the GNP in 1960; by 1978 this figure had grown to approximately 10%. Thus, imports and exports of goods and services today represent about 20% of this country's GNP. What this means is that one-third of all US crops is grown for export, and one in eight in American workers and manufacturing produces goods for export....Foreign earnings, as a percentage of total profits of American corporations have grown from 8.6% in 1947 to 12.1% in 1970. By 1978 the figure had grown to almost 33%. Annual sales of US multinationals operating abroad are substantially greater than export sales from the United States. In fact, they exceed the entire GNPs of all but a few countries. (US Senate, 1980)

On the other hand, to counter this clear growth in US export activity, we return the specifics of our growing deficit in the balance of payments.

> US exports as a percentage of total world trade have dropped from 18% in 1960 to 11.2% in 1978...After enjoying annual surpluses throughout this century, the US balance of trade began to experience deficits in the early 1970s. In 1978 this country experienced a record deficit of $28.5 billion. The projected deficit for 1979 is now about $25 billion [Note the actual estimated deficit in 1979 was $317 million, a clear difference from the projections. However, initial estimates indicate that a large portion of this improvement is a temporary one, a result of the return of capital to the United States from US-based multinational corporations.] In the 1980s the United States is likely to face increased competition internationally which could cause trade deficits larger than those experienced in the 1970s. Increased energy costs will force oil importing countries to be ever more export-conscious in an effort to pay for their oil imports. The new emphasis of many developing countries on export-oriented industrialization strategies will challenge the stability of the US manufacturing base, particularly in consumer goods and other products where advanced technology can be absorbed by foreign competitors. [emphasis added] (US Senate, 1980)

The Senate Committee on Governmental Affairs, in their report on reorganization of trade functions, went on to some of the more specific impacts of our failure to develop a coherent trade policy. As indicative of a broader problem within the United States,

> Continuing trade deficits cannot simply be explained away by pointing to the size of oil imports. US decline in world markets is apparent in such other areas as manufactured goods. In 1970 Germany moved ahead as the world's leading exporter of manufactured goods and has since widen its lead. The United States now appears ready

> to slip into third place in exports of manufactured goods, because Japanese sales were only $300 million less than US sales in 1978. In just three years, from 1975 to 1978, the US trade balance in manufactured goods actually dropped from roughly a $20 billion surplus to actual deficit of over $5.8 billion...US trade deficits are not simply a consequence of cyclical factors, but reflect a long-term erosion in the US competitive position. In recent years our annual rate of productivity increase, measured in output per manhour, has consistently lagged behind our trading partners....From 1972 to 1977, however, our annual productivity growth was only .6 of 1% per year. In 1979 our annual rate of productivity increase has been virtually stagnant....Investment in plant capital equipment as a percentage of GNP is lower in the United States than in most other developed countries....For every $1 billion of a trade deficit, the United States foregoes approximately 40,000 new jobs, $2 billion in GNP, and $400 million in Federal tax revenue. (US Senate, 1980)

These and other similarly dismal facts led to the Congressional approval of President Carter's Reorganization Plan No. 3 establishing a coherent, central source of foreign trade policy, centered in the Office of the US Trade Representative which is located in the Executive Office of the President. (See Figure 6-7)

Federal International Trade Organization Prior to 1980.

This reorganization was in direct response to the dysfunctional nature of the incoherent organization which existed through 1979. The following is a summary of the conditions prevailing up until the reorganization in which essentially no branch of the government considered international trade to be one of its major concerns.

> Developing and coordinating the implementation of international trade policy (was) not the primary mission of any department or agency of the government. Three agencies (dealt) primarily with trade matters, the STR (Special Trade Representative), the International Trade Commission, and the Export-Import Bank, but the scope of activities of each (was) too limited to deal comprehensively or effectively with all the elements of international trade policy.....Commerce (was) primarily concerned with the interest of US industry; Labor with workers; Treasury with tax and monetary relations; Defense with military security; and State with foreign relations. (This) means that there (was) no single agency to highlight important trade policy issues emerging in any of these agencies, to coordinate research and analysis on the issues, and to establish a clear set of trade priorities and related policy directives. Without centralized direction, inadequate research may be devoted to the trade issues most in need of investigation. Emerging trade issues may get lost in a department preoccupied with other problems more closely identified with its major mission. And trade policies in an area may vary from year to year depending on which agency or department is especially active at the moment in that particular area.
>
> As a result, important policy decisions may be deferred in the absence of consensus, or either an agency or the President may make a decision before the implication of the decision on US trading needs, and the perspectives of other agencies, are fully considered.

Office of the U. S. Trade Representative

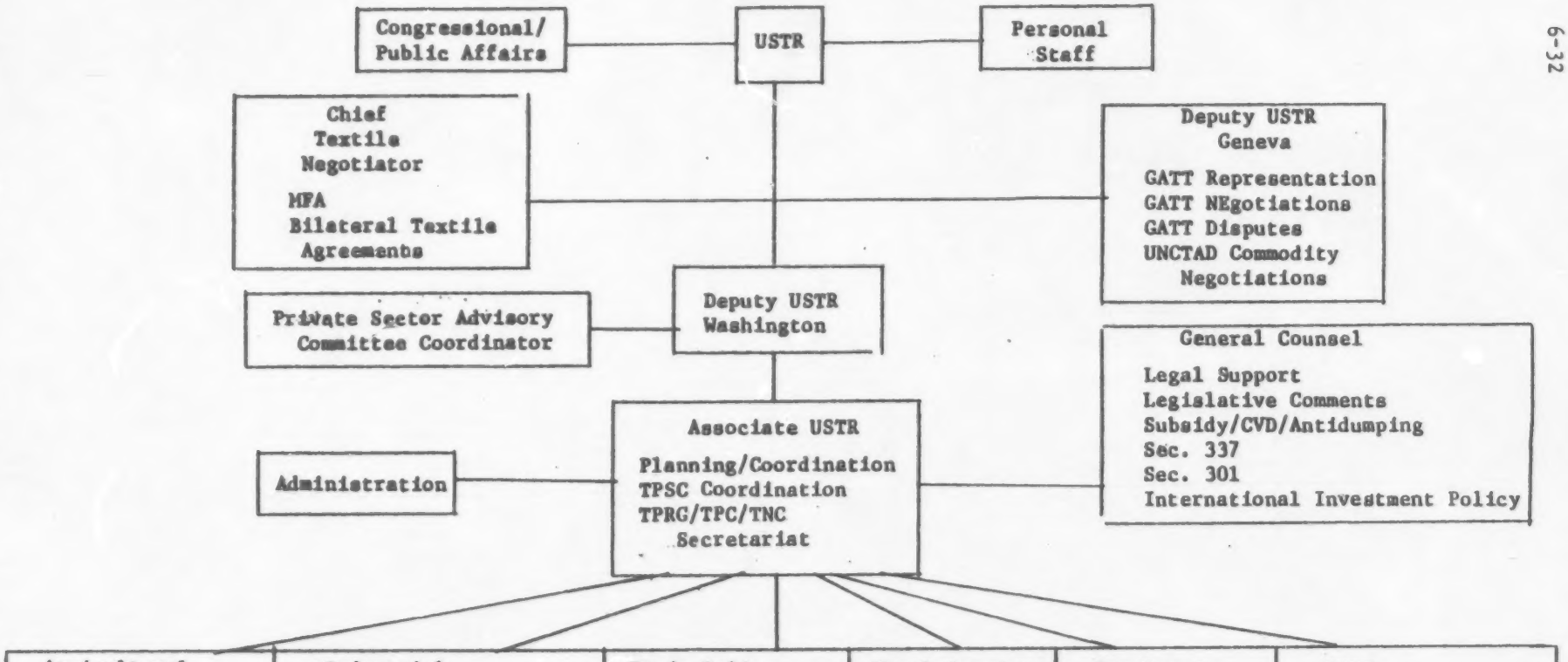


FIGURE 6-7

> [The Committee report goes on to provide an example of the development of commodity policy in 1975.]...While the Commerce Department was attempting to persuade Japan to restrain exports to the United States in a effort to balance trade with Japan, the Justice Department may have been cautioning Japan that undue export restraint may violate US antitrust laws....No one agency or official may be held accountable by Congress or the public for the overall effectiveness of US trade policy. There is no one official who can speak with the prestige and authority necessary to explain US trade policy to the country generally, or to potential exporters in particular. (US Senate, 1980)

The above has been the situation regarding the development of national trade policy. The following excerpt from the Senate Committee report discusses the state of affairs in 1979 for international representation of the United States, promotion of US exports, and administration of fair trade laws.

International Representation

> The responsibility for taking the lead role in negotiating trade agreements has been divided among three and sometimes four different agencies. Although STR (Special Trade Representative) has had responsibility for multilateral and some non-Communist bilateral trade negotiations, other departments take the lead in other trade-related negotiations. The State Department, backed by Treasury, Commerce, and Agriculture, assumes the lead in negotiating commodity agreements, as well as trade agreements with Communist contries. The Treasury Department with responsiblity for administration of the countervailing and anti-dumping statutes, has negotiated with foreign countries to reduce their subsidies, or to bring pressure on foreign industries to cease predatory pricing practices. Treasury, in addition, tries to negotiate with foreign governments agreements intended to reduce or control competition in government financing of export sales. The Commerce Department has also from time to time played an important role in negotiating trade agreements, including the US-USSR trade agreements in 1972.....Astute foreign negotiators are able to detect and to explore differences among US negotiators, thereby compromising our negotiating strength. The continued fragmentation of negotiating responsibility undermines US efforts to sustain a consistent and strong position in international trade negotiations.

Promotion of US Exports

> Today the US government spends about 100 of 1% of its budget on export promotion efforts. This is less than Japan, Italy, France, or the United Kingdom. A variety of agencies administer with varying success and attention the export promotion programs the United States does have.....Currently 85% of all American manufactured exports are accounted for by about 1900 companies. Among the 25,000 to 30,000 existing exporters, the 95% which are small and medium sized still account for only 15% of total exports. The Commerce Department estimated that there are an additional 18,000 small to medium sized manufacturers that could probably export, but which do not do so now. These figures suggest that the category of small to medium sized firms is one area where there is

considerable room for improvement in the US export promotion program.....Overseas market information and assistance from commercial attaches who are familiar with the language and customs in which they work can be a valuable help to companies seeking to increase their exports. The fact, however, that these services are apparently provided by the State Department through its commercial attaches means that assistance to US business seeking to export (is) split between the Departments of State and Commerce. The State Department does not have the day-to-day contact with domestic business in this country that Commerce does. As a result, the State Department is not as familiar with the needs of potential exporters as it needs to be in order to do a fully effective job. Furthermore, within the State Department commercial functions do not receive the highest priority. The positions are filled by Foreign Service officers who are discouraged from making a career in this field because service in the political field has traditionally been considered prestigous, and more likely to lead to promotions.....Export financing, which also significantly affects the level of US exports, is the responsibility of two other agencies. The United States may be the only major developed country that maintains separate institutions for financing and promoting exports. The Export-Import Bank is the primary official source for manufactured exports, while the Commodity Credit Corporation finances agricultural commodity exports. Coordinating export financing the responsiblity of the Treasury Department through its chairmanship of an inter-agency committee, the National Advisory Committee on International Monetary and Financial Policies (NAC). Export financing is viewed by the Treasury Department as much as an international monetary issue, as an export promotion issue. The STR which is most likely to emphasize the importance of an export credit financing to the overall trade posture of the United States, is not a member of the National Advisory Committee.

A similar separation exists between US support of investments abroad, and the US trade expansion programs, even though direct investments abroad have a significant impact on exports. The government's programs supporting and insuring US investments in developing countries are administered by the Overseas Private Investment Corporation (OPIC). OPIC is linked organizationally to this country's foreign assistance programs through the director of the International Development Cooperation Agency (IDCA), who chairs the OPIC board. The only link between OPIC and US trade policy is the presence of the Commerce Department on the eleven person OPIC board.

Administration of Fair Trade Laws

Six agencies play important roles in administering the programs that regulate imports or provide relief to firms and workers injured by both fair and unfair foreign competition. They are STR, Treasury (including the Customs Service), the International Trade Commission (ITC), Commerce, Agriculture, and Labor.....Both industry and labor have maintained that the Treasury Department administration of the anti-dumping act has been irregular. They point to the failure to collect anti-dumping duties already imposed as one of the most serious deficiencies. In 1971 there was an official finding that Japanese television sets were being sold in

the United States at less than fair value. Yet it was only in 1978 that the first dumping duties were actually assessed, effectively denying relief to affected domestic industry for seven years.

A recent GAO study concluded,

> The long periods of time required to conduct investigations, and delays averaging three to three and one half years in assessing duties after findings of dumping, make it highly improbable that US industry is being adequately protected by the act.

> ...(The GAO) cites figures indicating that between 1955 and 1965, when annual imports were less than $20 billion, Treasury processed an average of thirty-five cases each year. In 1977, when imports reached $146 billion, Treasury began thirty-three investigations, including twelve which were subsequently withdrawn due to the initiation of the steel trigger price mechanism. (US Senate, 1980)

In short, whatever lack of response to foreign trade opportunities there may have been on the part of the private sector, the Federal government more often than not appeared to exacerbate rather than improve our foreign trade difficulities. The author's own conversations during the course of this research with various foreign trade officials in the Federal government has essentially confirmed the remarks just quoted. If anything, these remarks seem to be mild. The author has listened to anecdotes demonstrating the fact that foreign interests, although wishing to purchase US products, frequently were forced to go to less desireable sources because of the inordinate delays imposed by the Federal government in arranging for export licenses. Particularly in such sensitive areas as the exportation of computers and associated hardware, where the government is justifiably concerned about re-export of the hardware to Communist bloc countries, the delays in obtaining export licenses can be particularly severe.

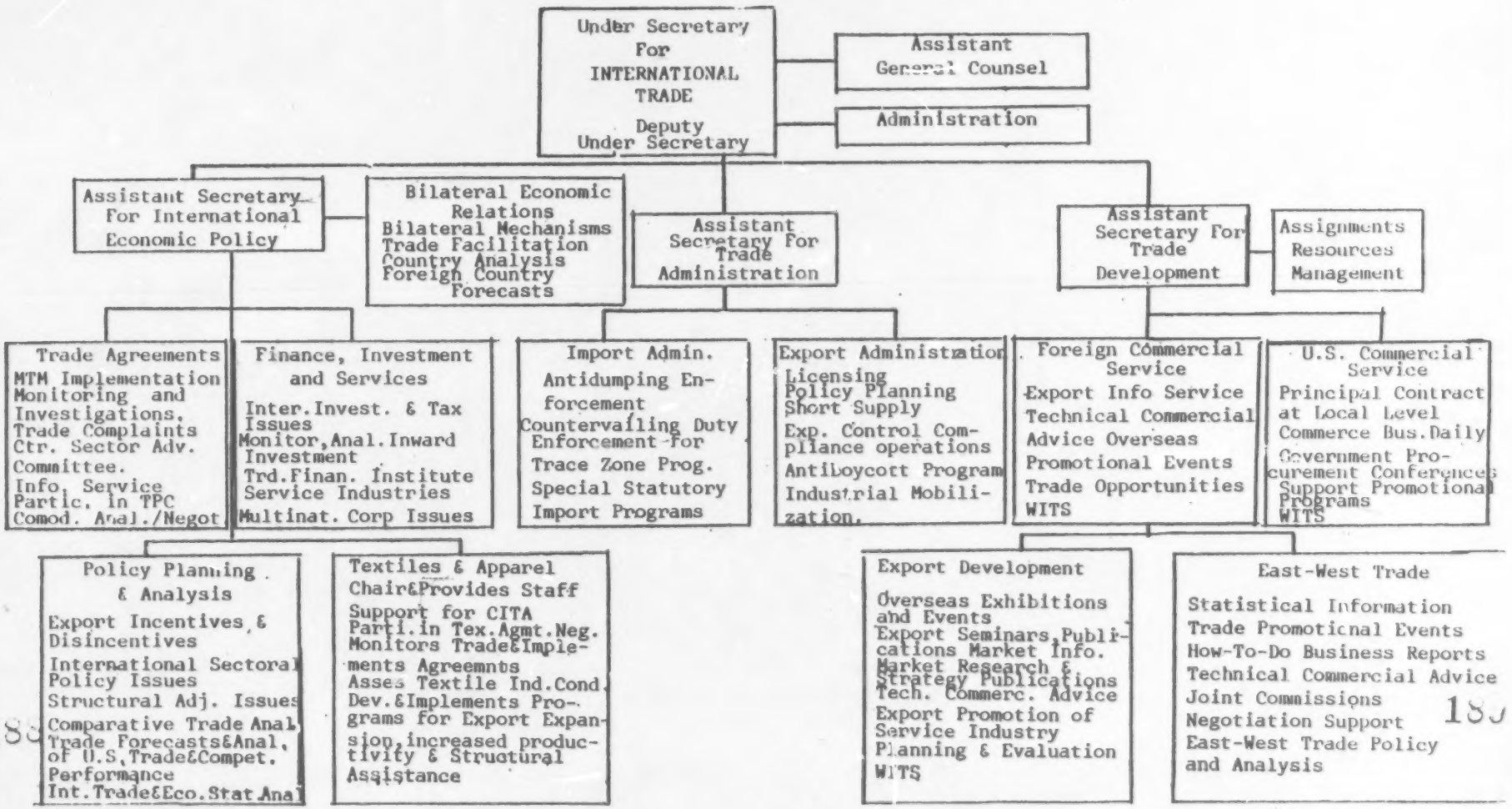
On the other hand, it is clear that the Federal government has been at least partially effective in promoting export trade. Interviews with several manufacturers and distributors of personal computers have shown that most have not had any particular difficulty in exporting their products. However, all of those interviewed were representatives of very active and forceful organizations in the field. Other organizations, representatives of which were not available for comment during the period of our research because of pending or current bankruptcy proceedings, appear to have had serious difficulty at least partially because of export problems. In any case, the primary issue is that of converting the Federal role in US international trade from at best a neutral one to that of a positive agency for improving our international trade position.

The Newly Organized Federal Response to International Trade Issues

The President's International Trade Reorganization Plan went into effect on January 1, 1980. Although the plan has not taken the ultimate step of setting up a single agency with entire responsiblity for international trade, as is the case with Japan and the countries of Western Europe, there are now just two agencies with clear responsibility for international trade functions. These are the Office of the US Trade Representative (USTR) in the White House and the Department of Commerce. These two agencies have the responsiblity for the development and implementation and day-to-day implementation of international trade policy, respectively. The organization

FIGURE 6-8

INTERNATIONAL TRADE ADMINISTRATION



under the US Trade Representative was shown in Figure 6-7. Figure 6-8 shows the organization of the International Trade Administration, headed by the Undersecretary of Commerce for International Trade.

The philosphy of this reorganization is summarized in the report the Senate Committeee on Governmental Affairs.

> The reorganization places a single individual with direct access to the President in charge with developing, and coordinating the implementation of, overall US trade policy. In the future the US Trade Representative (USTR) will provide the principal guidance on trade policy matters to the different agencies and departments of the government.
>
> The fact that the USTR will have as its sole mission the promotion of US international trade interests should help focus the attention of the government and the country on international trade matters. It should help promote full consideration of trade issues whenever and wherever necessary. No longer will key trade functions be located in a large department like State or Treasury where it is just one of a number of interests of a department. In the future there will be less likelihood that trade issues will be overlooked or sacrificed at an early stage of a department's internal consideration of a matter because other interests have priority. Undoubtedly trade considerations will in some cases have to be reconciled with foreign policy or other concerns. But the reorganization should help insure that the trade issues will at least get more visibility, and more thorough consideration, before any decision is made.
>
> The lead role of the USTR for the development of policy will come from a number of sources. The plan specifically assigns to the USTR primary responsiblity 'for developing and for coordinating the implementation of United States international trade policy.' It will be the responsibility of the USTR to define the issues, set the agendas, and to adopt a comprehensive trade policy the United States will need to compete successfully in international trade. The plan further provides that the USTR shall be 'the principal advisor to the President on international trade policy,' and further provides that the USTR shall advise the President on the impact of any other policies of the US government on international trade.
>
> The plan authorizes the USTR to issue policy guidelines on major trade issues, and provides that such guidelines shall 'determine the policy of the United States with respect to international trade issues.' The USTR will have this authority in connection with the trade aspects of policies or programs affecting such matters as the ability of the United States to expand its exports, the ability of the United States to monitor compliance by other countries with recently adopted MTN (Multilateral Trade Negotiations) or other international agreements, import relief policies, the identification and analysis of trade issues, international trade issues involving energy, or trade issues generally, whether they are dealt with bilaterally or multilaterally. (US Senate, 1980)

In short, the USTR, although with considerably strengthened authority relative to the former state of affairs, is hardly an international trade czar. One might interpret the report of the Senate Committee on Governmental Affairs as pointing out that the USTR has now been elevated to the position of an important player in what Allison calls the game of governmental

bureaucratic politics. (Where one stands depends on where one sits.) Admittedly, the USTR as a new player in the game of international trade has more chips with which to play; however, it is not at all clear at this stage whether the array of other peripheral priorities and perceptions and various stakeholders (to be discussed later) will allow sufficient rapidity and force of action to counter existing and future trade competition from potential competitors, especially Japan.

3.2.2. Responses by Other Governments

Japan and Asia

The cooperation between Japanese government and industry is legendary, resulting in the appellation, "Japan, Inc." The Japanese government/industry combination is seen by many as one that is almost unbeatable. In every field except, possibly, sports requiring large physical size, a Japanese government/industry decision to enter a particular field has ended with their domination or a close second place within a matter of a few years. At the end of the Second World War, the gross national product of Japan was just over one-third that of France. By the late 1970s it had grown to more than half the size of the US GNP. The Japanese have taken over world leadership in steel, shipping, motorcycles, cameras, consumer electronics, optical instruments, and are beginning to surpass the United States in the production of automobiles. The typical scenario for development of a new industry by the Japanese is as follows.

First, as a general rule the Japanese people are inveterate and enthusiastic gatherers of information and knowledge of all types, whether or not any specific set of information appears to be immediately useful. Both the Japanese government and industry support a number of "think tanks" whose primary role is to collect and sift information relevant to particular industry or government goals. There is close cooperation between large industrial firms, trading companies, and government ministries. In establishing national goals such as the one on development of the computer indusry mentioned earlier, once a national goal has been established it is taken to heart by essentially everyone in the government or industry connected with the satisfaction of the goal. Information gathering and training programs are sponsored at all levels and performed generally with considerable thoroughness. Great attention is paid to developments in other countries. Experts in the field of interest from other countries are invited to Japan to give lectures and/or their writings are quickly translated for consumption by those in the industry or by the populace in general. As an example, "In the late 1960s,...when computers first came to widespread attention, over one million copies of the textbook to accompany the educational television program on computers were sold in one year." (Vogel, 1979).

The extensive information gathering is rapidly turned into the development of production techniques. Since, regardless of the amount and quality of incoming information, errors are bound to be made in developing a new industry and costs for the initial product are likely to be relatively high, most initial production of the products in question goes to domestic consumption. Part of these initial development costs are subsidized by low-interest loans or outright grants from the Japanese government. Furthermore, the practice in Japanese industry is to have levels of debt which would be considered unconscionable in the United States. Where a typical debt to equity ratio in the US technology intensive industries is about one/six, the ratio in the leading Japanese electronics companies is as high as 5.6:1 and averages 3.5:1 among the top four. This is due partly to encouragement of these ratios by the government and to the greater availability of debt capital

in Japan because of the national tendency toward a high rate of consumer savings. For example, the savings rate for private citizens in Japan in 1977 was 21.2% as compared with a rate of 5.1% in the United States (in terms of ratio of personal savings to disposable personal income). Of the top seven OECD countries, Japan has the highest rate of national savings; the United States the lowest. At the end of 1979, the personal savings rate in the US was down to 3.2%. Personal savings make up about one-third of the total capital available for investment in the US. Furthermore, the Japanese government exerts great control over the selection of those companies to which Japanese commerical banks make loans. At the other end of the capital investment picture, a typical Japanese company gets less than one-sixth of its capital from stock, as compared with one-half or more in major US firms (Vogel, 1979) This greater dependence on debt capital in Japan is accompanied by reduced pressure for short-term growth (of the sort usually generated by stockholders).

> How has the Japanese government been able to direct lending practices of private banks? It has been able to do so quite easily because during most of the period of high growth, there were such pressures on the commercial banks for funds that they loaned in excess of their stipulated ratio and had to borrow from the Bank of Japan to cover commitments. Japan's central bank is not an independent central bank, but rather one which follows the Ministry of Finance policy. Therefore, the condition imposed for provision of the extra funds which the commercial banks were frequently seeking, was that the loan policy of the commercial banks be in accordance with government priorities.
>
> Commercial banks were able to get an explicit 'reading' of the industries and companies which the government wished to favor from noting the companies to which the Japan Development Bank made loans. (US Comptroller General, 1979)

The Japanese Ministry of International Trade and Industry (MITI) plays a major role in this development. It acts to influence the decisions of the Ministry of Finance, as just discussed. It also influences a number of tax-related incentives to industry to develop in specific directions. To begin with, the corporate tax rate in Japan is slightly lower than that in the United States (40% and 46%, respectively, on undistributed profits). In addition, Japanese firms typically take double declining balance depreciation on capital equipment. In those industries receiving favorable treatment from the Japanese government there is an additional 25% first year "rationalization allowance" for that equipment which is of particular use to development of the growing industry. Although no longer in use this allowance was given to Japanese firms between 1952 and 1976 and included the electronics industry. Furthermore, until about 1972, firms with strong export performance were allowed to take additional tax write-offs and in some cases deferred income. Finally, additional rates of accelerated depreciation were allowed for the companies with strong export performance until 1971. By that time the major Japanese firms had reached extraordinary health and were responsible for the growing Japanese surplus in international balance of payments. The additional incentive were consequently dropped; however, the continued use of ready access to capital via commercial banks is still a major government tool.

The Japanese government also influences the rate of personal savings. Japanese families are exempt from taxes on the first $5,000 of interest income as compared with a $200 allowance in the US.

The Semiconductor Industry Association has the following reaction to

this practice:

> The key concern of the industry is its severe disadvantage in competing with aggressively-growing, government subsidized foreign companies which have assured sources of capital and thus can price their products without concern for current earnings. The profitability of US semiconductors firms is double or triple the profitability of the Japanese and European firms and the US return on equity is double its foreign competition, despite almost exclusive US reliance on equity capital.(Noyce, 1980)

Table 6-9 shows the situation as presented by the SIA. The combination of this easy access to capital, with government loan guarantees, the practice of allowing the infant industry to get through its growing pains by protected internal consumption, government subsidy of research and development for the preferred product areas, and low export profit margins, as reflected in the return on equity are all listed as major, government-induced, alterations of the relative competitive positions of Japanese and US manufacturers.

Europe

The situation is similar in Europe, but the level and scope of government support of European industry is not so intense as in Japan. Nevertheless, it is significant. Table 6-10 (an extended version of Table 6-5) summarizes known government subsidies and loans for the semiconductor industries in Europe, Japan and the United States as of March, 1979. Neverthless, the European Economic Community is definitely engaged in exhorting its member countries toward development of a collective capability in "Peri-Informatics" (peripherals, terminals, mini- and microcomputers), software, and telecommunications equipment (the latter involvement spurred a recent remark by Representative Van Deerlin, concerning lobbying on his proposed revisions to the 1934 Communications Act, to the effect that European suppliers of telecommunications equipment were exerting undue influence in opposition to the bill). However, the EEC response tends to be more reactive and protective rather than expansive. For example, in the recent position paper of the Commission of the European Communities the proposed community response was summarized as follows:

> It is important to support the creation of a European information industry
>
> - By helping the private sector to invest in the creation of data bases and associated services;
>
> - In making sure that the small and medium sized enterprises have access to the information required;
>
> - By promoting accessible public data bases, the coordination and nationalization of policies in the members states and joint community action where appropriate;
>
> - By encouraging the European information industry to export its products to the world at large.(Commission of European Communities, 1979)

The level of encouragement discussed, although more restrained than that used

TABLE 6-9

	1978 Average After Tax Return on Equity	1978 After Tax Earnings As % of Sales	1978 Debt/Equity Ratio
Six U.S. Companies	16.3%	6.4%	16%
Four Japanese Companies	8.0%	1.9%	345%
Two European Companies	9.6%	2.4%	47%

/Source: Noyce, 1980/

TABLE 6-10

. GOVERNMENT SUBSIDIES AND LOANS FOR SEMICONDUCTORS

PROPOSED & ACTUALS

COUNTRY	MAIN RECIPIENT	STATE FUNDS	TERM	REFERENCE
EEC	IN PLANNING STAGES			ROCKWELL
GERMANY		$100 MILLION ($30 - $40 MILLION YEARLY)	3 YEARS	EL 9-28-78 EW 7-5-78,7-26-78
ITALY	SGS-ATES (LOAN & SUBSIDIES)	$135 MILLION	4 YEARS	
FRANCE	ST GOBAIN PONT A MOUSSON	$50 MILLION		ECON 8-5-78,EW 2-21-79
	MINISTRY OF INDUSTRY TO THOMSPSON CSF-SSC	$120 MILLION TO		ECON 8-5-78
	THOMPSON CSF + CEA (SESCOSEM/EFCIS)	$200 MILLION	5 YEARS	EW 11-15-79
	RADIOTECHNIQUE COMPELEC	$25 MILLION		EW 7-5-78, 2-21-79
UK	UK TOTAL $330 M		3 YEARS	EW 2-21-79
	NEB AVAILABLE FUNDS LIMIT: $6B			EW 12-13-78
	NEB TO INSAC (SOFTWARE CONSORTIUM)	$ 40 MILLION	3 YEARS	EL 9-28-78
	NEB TO INMOS LTD.	$ 90 MILLION	BY 1981	BW 7-3-78 EN 6-5-78, 7-3-78
	NEB TO PLESSEY (LOAN)	$ 40 MILLION		ECON 7- -78
	DOI TO MISP (MICROELECTRONIC INDUSTRY SUPPORT PROGRAMME)	$140 MILLION	5 YEARS	EW 8-2-78, 12-13-78
	DOI TO MAP (uP APPLICATIONS PROJECT)	$180 MILLION		EW 12-13-78
	E-BEAM FAB TECHNIQUES	$ 1.8 MILLION		EL 9-28-78
	NCC - AWARENESS PROGRAM (SOFTWARE TRNG)	$ 90 MILLION		EW 12-13-78
JAPAN	VLSI SUBSIDY (LOAN)	$250 MILLION	4 YEARS	ROCKWELL
KOREA	GOLD STAR, ET AL (WORLD BANK LOAN)	$600 MILLION		ICE
USA	VHSI NBS	$250 MILLION	5 YEARS	
	TOTAL GOVERNMENT EXPENDITURES WORLDWIDE FOR PROMOTING SEMICONDUCTORS	$2.3 BILLION+	3 - 5 YEARS	

EW - ELECTRONICS WKLY BW - BUSINESS WEEK EN - ELECTRONIC NEWS ECON - ECONOMIST EL - ELECTRONICS MAG

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by Japan, is still significant, particularly in Germany, France, and the United Kingdom. However, in the UK events have taken a recent turn which might ultimately act to weaken their comptetive role in computers and electronics.

There is one intriguing question which we should raise, even though there are no data available at present with which to address to the issue. This is, to what extent will the economic "threat" posed by US and Japanese dominance in the microelectronics and computer industries, and further expressed at the individual consumer level by US dominance of personal computer sales in Europe, cause a political solidification of the EEC? It is clear that the potential adverse impacts of computers on employment in Europe is a major concern of the governments and labor unions in Western Europe. As stated previously, the general attitude at the moment appears to be one of accepting the inevitability of these technologies and assuring that the EEC gets an appropriate share of the pie. The Commission of the European Communities is currently urging the member countries to unite, resolving transnational differences, in reaction to this challenge. The rapid increase in popularity of personal computers in Europe may act to develop broader public support for these measures.

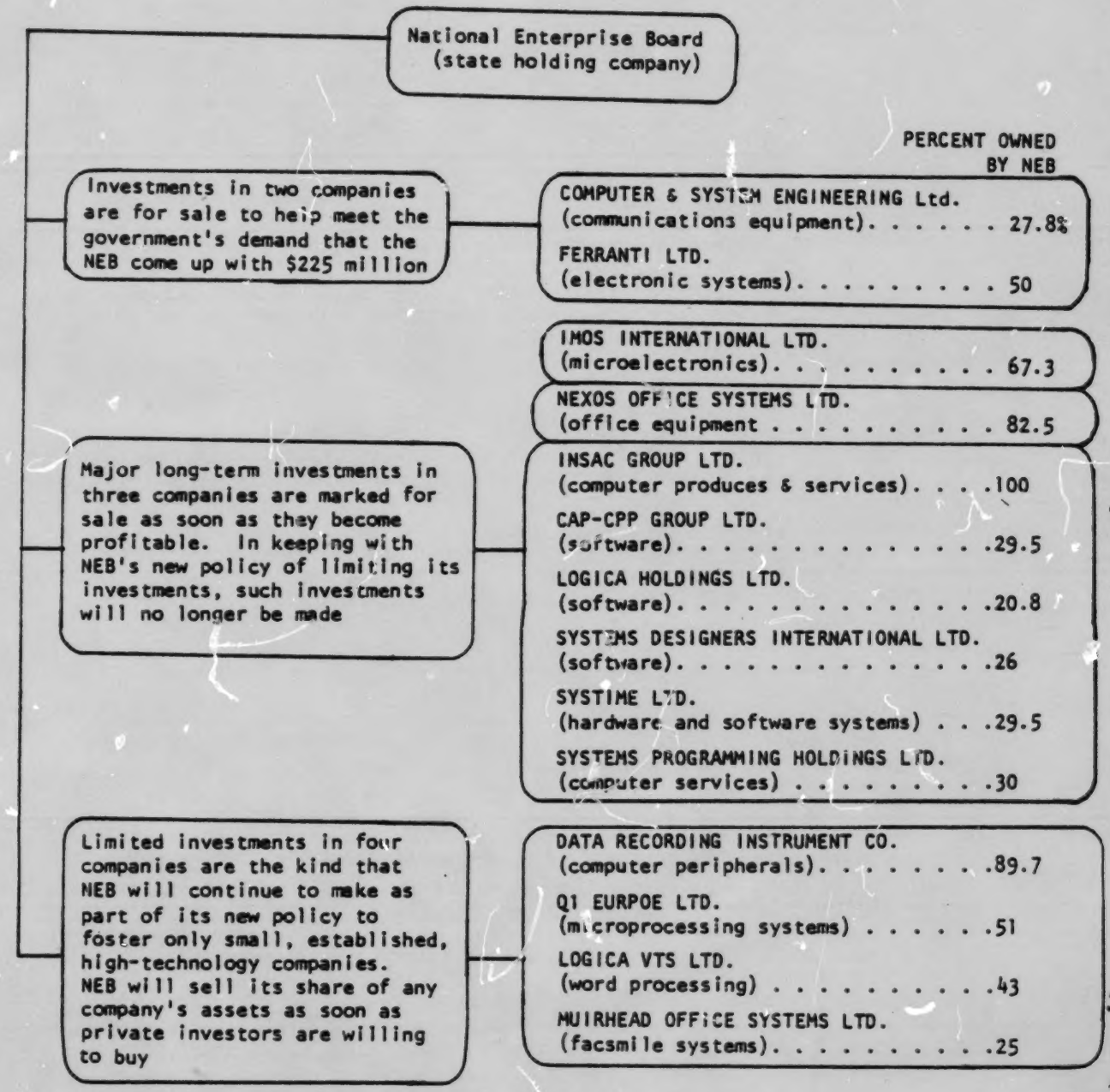
The chief mechanism for government support of investments in private industry in the UK has been the National Enterprise Board (NEB) which is a government holding company. Until recently, NEB planned to spend up to $6.8 billion on the British electronics industry. NEB spending through the 70s in computers and semiconductors has been in the order of $1 billion. However, under the conservative government the NEB plans to cut spending by 80%, with much of the budget cut acting to reduce funding from electronics companies. The future policy of the board apparently is to emphasize near-term payback of its investments and to invest in the future only in product developments which promise a high, short-term, rate of return. To some analysts this presents the interesting spectacle of the US and the UK vying with each other to determine which government can, through its polices, create the most havoc in its key developing industries. Figure 6-9 shows the current plans for the NEB to divest itself of its existing interests in the electronics industry and to limit its future investments. In short, the government of the UK have apparently decided that government holdings should be minimized and that, if there is even the slightest chance of private capital becoming available (or the slightest chance that private capital ought to be available) then the government should have no role in the matter. This situation consequently becomes much closer to that generally obtaining in the United States where, as one wag put it, "The only time the Federal government will support a development project is when there is absolutely no commercial utility to the results."(Remark made to the author by a Federal research manager).

The UK government have not entirely withdrawn its support for developments in the microelectronics and computer industries. Programs outside those supported thourgh the NEB are still continuing with little disruption as yet; support to microelectronics firms will total about $250 million over the next four years.

All of the above relates to the development of microelectronics and computer industries in general. None of the governments in other countries has developed specific policies relating to the support of the personal computer industry. It is probable that no policies with this specificity of support will be promulgated in the next few years, since personal computers are still generally considered to form a sub-element of the computer and semiconductor industries themselves. However, there is strong interest in Europe particularly concerning the effects of personal computers and microelectronics, particularly as they affect jobs (see Section 4.2).

FIGURE 6-9

THE BRITISH GOVERNMENT TRIMS
ITS ROLE IN THE INFORMATION PROCESSING INDUSTRY


National Enterprise Board
(state holding company)
PERCENT OWNED BY NEB
Investments in two companies are for sale to help meet the government's demand that the NEB come up with $225 million
COMPUTER & SYSTEM ENGINEERING Ltd. (communications equipment). 27.8%
FERRANTI LTD. (electronic systems). 50
IMOS INTERNATIONAL LTD. (microelectronics). 67.3
NEXOS OFFICE SYSTEMS LTD. (office equipment 82.5
Major long-term investments in three companies are marked for sale as soon as they become profitable. In keeping with NEB's new policy of limiting its investments, such investments will no longer be made
INSAC GROUP LTD. (computer produces & services). . . .100
CAP-CPP GROUP LTD. (software). 29.5
LOGICA HOLDINGS LTD. (software). 20.8
SYSTEMS DESIGNERS INTERNATIONAL LTD. (software). 26
SYSTIME LTD. (hardware and software systems) . . .29.5
SYSTEMS PROGRAMMING HOLDINGS LTD. (computer services) 30
Limited investments in four companies are the kind that NEB will continue to make as part of its new policy to foster only small, established, high-technology companies. NEB will sell its share of any company's assets as soon as private investors are willing to buy
DATA RECORDING INSTRUMENT CO. (computer peripherals). 89.7
Q1 EURPOE LTD. (microprocessing systems) 51
LOGICA VTS LTD. (word processing) 43
MUIRHEAD OFFICE SYSTEMS LTD. (facsmile systems). 25

/SOURCE: Business Week, 3-24-80

Government agencies find themselves torn between the desire to effectively compete with the United States and Japan in these industries and the need to avoid increased unemployment resulting from the applications of the technologies. If the latter need becomes dominant, it is conceivable that these governments might adopt policies tending to restrict the use of these technologies and to stifle the development (or at least the development for internal consumption) of their own microelectronics and computer industries.

4. Stakeholders

From the point of view of international trade issues, there are essentially four groups of private sector stakeholders to consider: the microelectronics industry, the computer industry, the distribution and retail industry, and consumers. For all of these stakeholders the primary interest is economic. For the first three groups the central question is whether each group can produce and/or distribute its product profitably under current conditions of international trade. For the consumer group the issue is one of making a choice between the capabilities offered at various price ranges by domestic and foreign companies. To these groups is added the primary public sector stakeholders, the Federal government. Table 6-11 summarizes their objectives. Table 6-12 gives further details on some of the stakeholders.

4.1. Microelectronics Industry

The various technological possiblities of personal computers which have been described previously in this report all depend for their realization on a continued growth in demand for continually more sophisticated microelectronics components. Thus far, with the exception of a brief period of over-supply in the mid-70s, demand for microelectronics products has greatly exceeded supply. In fact, the inability of US microelectronics manufacturers to meet the international demand for their products, particularly memory chips, is considered to have been the prime factor in the capture of a significant portion of the international market by Japanese manufacturers. Thus, a primary concern of US manufacturers, as reviewed in the previous section, has been acquisition of sufficient supplies of capital to maintain an adequate response to international demand. This is the primary concern expressed by spokesmen of the industry.

Concerns have also been expressed that demand will falter in the future because the requirement for ever increasing sophistication will wane. Although this is possible, the implication reflects a choice in engineering approach rather than a fundamental change in the nature of the market. That is, the demand for increasing density of components on a microelectronics chip will apparently continue to hold for several years. The issue is whether the increased number of components on an given chip will be devoted to more sophisticated tasks or to greater quantities of a well-defined task, such as increased size of memory, rather than a very elaborate, microelectronic-embodied operating system. These are all clearly issues which will be resolved by market processes rather than by governmental action.

The semiconductor industry, together with the Electronics Industry Association (the latter also representing other aspects of the electronics industry), have been quite articulate in expressing their concerns in regard to the possibilities for international competition, particularly from the Japanese. The SIA, the EIA, and others have made presentations to Congress and have informed their members of the status, possibilities, and progress concerning these issues. Their concerns with import competition are not usually presented in terms which deal specifically with personal computers.

TABLE 6-11

Stakeholders - International Trade

-Partial List-

Actor/Stakeholder	Function	Objectives
PC Consumer		
Home	End User	Entertainment, education, household information control functions, electronic mail. Brand name conscious.
Small Business	End User	General business information handling, emphasis on text processing, financial and inventory control. PCs as means for "resident expertise" embodied in software. Price conscious
Large Organization	End User	PCs as component in distributed processing system, standalone systems for local office management, data entry, records keeping. Seen as tool for increasing information worker productivity. More sophisticated cost/performance analysis before purchase.
PC Producers		
Hardware Manufacturer	OEM	Assemble attractive hardware & software package for one or more of above markets. Try to control parts procurement, timing, financing, minimize direct end user interaction, bundle software into package or otherwise control software to maintain uniqueness. In U.S. case, try to prevent foreign competition; in foreign case, try to break into U.S. market with low cost, high cost, high volume product to leverage into higher margin, larger system sales.
	Components	PCs now seen as small portion of total microprocessor market. New CPU chips, memory, etc. developed for higher volume areas (auto industry, smart appliances). As market increases so will attention paid to PC-particular products. Foreign competition

TABLE 6-11 (Cont'd)

Actor/Stakeholder	Function	Objectives
PC Producers		
Hardware Manufacturer	Components (cont'd)	threats growing consideration, especially for microprocessor manufacturers. Press for better copyright, patent, tariff protection.
Software House	Producer of systems, applications software	Produce unique software or software sets tailored to one or more segments of above markets (e.g., games, interactive graphics, other entertainment modules, business applications, systems programs, etc.) Major concern with protection of intellectual property by copyright, patent, encryption, etc. Try to act as source for major OEMs, avoid foreign competition.
Federal Government		
Dept. of Commerce Economic Development Administration	Assistance	Aid foreign trade-injured firms through expert advice, loans, loan guarantees. Current law requires that absolute losses in business must have already occurred before aid can be given (Barn door syndrome).
National Bureau of Standards	Standards Setting	Act to increase quality of PC products, produced in U.S. Set standards to aid in US technological superiority. Develop standards such that intra U.S. competition is not stifled. Possible means for reducing import competition, increasing exports.

TABLE 6-12

International Trade

List of Specific Stakeholders

INDUSTRIAL

Microelectronics Manufacturers

INTEL	25% of memory market
National Semiconductor	X% of CPU, I/O market
Exxon/Zilog	5% of memory market
UTC/MOSTEK	12% of memory market
TI	14% of memory market
Fairchild	
Advanced Micro Devices	
Nippon Electric	5% of memory market
Motorola	5% of memory market

Primary PC OEMS (in estimated order of market share)

Tandy/Radio Shack	40% of PC market
Apple, Inc.	
Commodore/PET	
NorthStar	
Cromemco	
DEC	
Data General, Hewlett Packard	
IBM	

Rather, they treat the development of microelectronics in general. One would expect their concern with applications of personal computers to increase generally in proportion to the increase, if any, in the share of their market which personal computers represent.

4.2. Computer Industry

The computer industry has well established relationships in international trade, dominated by IBM. The industry, at least the mainframe and minicomputer industry, is also characterized by a large number of multinational corporations: Amdahl, Borroughs, CDC, DEC, Honeywell, and IBM as major examples. The top seven computer manufacturers account for about 80% of total world data processing revenues. (Datamation, May 25, 1979) However, as mentioned earlier, competition from firms based outside the United States is steadily eroding their market share. For the most part, these dominant manufacturers in the computer industry have not entered the personal computer market. Consequently, they have no specific existing interest in the international trade aspects of personal computers. This interest would be expected to change only when, or if, they decide to enter the field.

As mentioned earlier, personal computer manufacturers, following the traditional pattern of developments of US firms, have concentrated on domestic sales, although some of the more enterprising manufacturers are already making extensive plans to expand their export markets. None of the manufacturers interviewed by the USC research team expresses any particular concern at this point over undue competition from foreign firms. This is a situation typical of a rapidly expanding market where demand appears to far exceed supply, so that the prevailing attitude is that there is room for all comers. The USC research team knows of only two personal computer systems in the European market which are manufactured outside the United States. One is the Scandia Metric A&C 80 (which uses many US manufactured microelectronics components) with sales of about 10,000 units as of early 1980, and a personal computer manufactured by Sharp, sales unkown. Neither European nor Japanese manufactured personal computers have appeared in the United States to any extent as of this writing, although it is anticipated that a personal computer manufactured by NEC, which was introduced in Japan in November, 1979, may appear in the US market in the second half of 1980. Past experience with recent introductions of computer peripheral equipment by Japanese manufacturers leads the author to believe that a Japanese personal computer will provide serious technological competition to existing US manufactured products.

Unlike the manufacturers of computer hardware, independent computer software houses, particularly those dealing in personal computer software, do not constitute a monolithic, well organized industrial block well equipped to deal in international trade. Because of the great ambiguities even in domestic protection of software by patent or copyright, the future course development of the domestic software industry is uncertain. It is characterized by a relatively large number of small, independent firms at this juncture (like the personal computer industry in general). There are no key spokesperson nor well organized industry associations for either the personal compute software or hardware producers. Like most infant industries they are underrepresented in government circles.

4.3. Distributors

There are essentially five modes of distribution of personal computers in the United States: direct sales from manufacturers, sales through

independent brokers or retailers, through manufacturer-operated stores, through independent retail chains of computer stores, and through chains of general retailers. The predominant mode of distribution at the early stages of development of the personal computer industry was direct sales from the manufacturer. Manufacturer-operated retail stores range from the few stores operated by the Digital Equipment Corporation to the extensive chain operated by Tandy which distributes its computers both through its general purpose stores and a small, but increasing number of computer-only stores. Private computer retailers range from individually owned computer stores to chains such as the Byte Shops and Computerland stores. Finally, national general retailers such as Sears and Montgomery Wards have also begun to retail personal computers.

Manufacturer-owned distribution points can, of course, restrict their sales to their own products and consequently can restrict competition from other countries to the extent that they retain customers loyal to their products. For the rest of the distribution chain, however, it is in the best economic interests of the distributor to handle only those products, foreign or domestic, which provide the highest rate of return. Although US manufactured products are clearly dominant at the moment, there is no reason to believe that imports of suitable quality and price might not displace US manufactured products in the future. As is the case with the producers of personal computer hardware and software, there are not as yet any national organizations equipped to lobby effectively for a Federal role in the protection or development of their particular interests.

4.4. Consumers

It has been amply demonstrated in the past that there is no particular sentiment on the part of American consumers to prefer US manufactured products if a foreign manufactured product is available at a lower or the same price and at equal or superior quality, respectively. There is no reason to believe that these consumer attitudes will be any different in the personal computer industry than they have been in other areas of consumer electronics. There may be greater insistence on US manufactured products for personal computers used in business applications to the extent that American consumers concern themselves with the use of US produced software. However, wherever hardware produced by foreign competitors is independent of the origin of the software used with it, the attitudes of business purchasers are likely to be similar to those of American consumers in general.

Straitened economic conditions, such as continuing high inflation and interest rates, are likely to make the consumer computer market even more price-sensitive, in addition to influencing the ability of US personal computer and semiconductor industries to compete. Thus, lower cost imports might more easily increase their market share under these conditions. On the other hand, continuing development of public awareness of the sources of a chronic US imbalance in international payments may result in a growing "buy American" sentiment on the part of consumers. We have not been able to develop adequate measures to judge the relative influence of these externalities at this point.

5 Policy and Technological Options

The international trade issues relevant to personal computer technologies can be grouped into two categories: those issues which directly relate to international trade policy, and those which deal with industrial policy; the basic health of the U.S. personal computer and underlying

technogically intensive industries. Unfortunately, in the past, the problems of international trade have been looked upon - and dealt with - by Congress and by many policy analysts solely as trade issues. The underlying policy issues relating to the general economic health of an industry have been neglected or, at least, divorced from international trade considerations except where industries have been terminally ill (as with the Trade Adjustment Act). Generally, the symptoms have been treated rather than the more fundamental causes.

5.1 Industrial Policy: Maintenance of Primary Technological Superiority

The underlying issue of the Federal role in maintenance of U.S. technological superiority falls broadly across the government, but U.S. policy toward scientific and technological innovation, particularly the production and diffusion aspects of innovation, plays a central role. In the Executive Branch this issue could logically involve the Office of Science and Technology Policy, the National Science Foundation, the Department of Defense, NASA, the Department of the Treasury, the Department of Justice, the Small Business Administration, and several components of the Department of Commerce which are ordinarily not thought of as directly involved in international trade issues. Several Congressional Committees have existing or potential interests in these areas.

5.1.1 General Issues

Under true free market conditions, in which there are absolutely no artificial modifications of the price of a product (and where potential consumers have essentially perfect information about, and access to, available products), a product which is optimized in design and price for the perceived needs of the market population will rapidly gain dominance over less well qualified products. The better technology will replace its less capable, lower quality competitors even in cases where the better version may have a higher initial cost. The United States clearly has the best products in the personal computer industry at present. The central issues are whether the U. S. will have the basic capability to maintain its position and whether the market is or will remain truly free so that the law of comparative advantage is free of political modifications.

Although the countries in western Europe, particularly Germany and France, present growing competition to the United States, Japan is by far the most formidable near term competitor and will be discussed as the prototypical case. The primary threat from Japan to U.S. dominance of the personal computer market comes from the demonstrated and growing Japanese industrial ability and innovativeness and from the restraints on free trade imposed by the Japanese government. The overall Japanese strategy is invariably, on an industry-wide basis, to forego short-term return in favor of the prospect of subsequent domination of the market. That this approach has been eminently practical has been covered in previous pages.

In the early 1960's the Japanese government and industry mutually decided that further economic development required development of a superior technological capability. Intensive efforts were then made to train scientists and engineers so that the development could occur. At present Japan has approximately as many scientists and engineers engaged in non-defense research and development as does the United States even though it has only half the population. Although the United States is well ahead, by an order of magnitude, in the production of Nobel laureates, the Japanese are

clearly attaining parity or even superiority in many areas of applied high technology. (National Science Board, 1978).

According to Vogel, this rapid evolution of a superior Japanese technological capability is only partially due to specific government financial support and encouragement of forms of industrial cooperation which would be counter to U.S. antitrust laws (Vogel, 1979). Vogel attributes a major fraction of Japanese development to basic and pervasive attitudes of cooperativeness and consentaneousness on the part of government and industry officials and workers. There is insufficient space here to go into this aspect of growing Japanese technological competitiveness except to point out that the entire population of the United States must seriously consider changing its attitudes toward intra-industry and government-industry cooperation, including relationships between management and labor, if it is to successfully meet this challenge. Federal policies alone are not likely to be able to reverse the trends just described; they must be matched by general changes in attitudes toward innovation in order to be successful.

Japan and the EEC countries frequently level the same charges against the United States that U.S. industry representatives have aimed at Japan: that the U.S. government gives massive support to new technological developments. A frequent target of this criticism of the United States by other countries is the past support of the electronics and computer industries by NASA and the Department of Defense. There is no question that support by these agencies of basic technological developments in the computer and microelectronics industries has been fundamental in initiating their growth. However, beyond development of the basic technologies, it is not at all clear that NASA and DOD support of applied technological development for their specific mission areas has any direct relationship to increasing the competitiveness of US industry in the commercial sector, with the exception of the technology transfer programs of NASA and, to a lesser extent, of DOD. These, however, have not been particularly major factors in the past.

There are those who argue that DOD-and NASA-oriented developmental efforts, combined with a lagging U.S. production of qualified scientists and engineers, has resulted in a weakening of our private sector position relative to
Japan by siphoning off scarce scientific and technological talent. There are also countercharges by those in DOD who argue that the concentration of U.S. firms on microelectronics, has weakened defense technology. The recent DOD initiative for the development of VHLSI technology is a manifestation of this concern.

Notwithstanding these internal differences, the general consequences of actions by the U.S. Government seem to have been as follows:

"Japan encourages its strong industries; the United States protects its weak ones." (Comptroller General, 1979)

In April, 1978, because of a growing realization of fundamental differences such as these, President Carter ordered a study of the role of government in furthering technological innovation in the United States. This study (completed in October, 1979) and related activity in Congress have resulted in increased appropriations and expanded roles for existing Department of Commerce and National Science Foundation programs toward increasing the rate of innovation. Yet, it appears that these programs, at least in their present form, are just starting to break with the long standing tradition of avoiding any possible imputation of direct support of our strongest industries. However, there are a number of policy options for increasing the health of our strongest technological industries; options which, although possibly involving industry-specific incentives, are far short of any real or implied industry/government "collusion" of the type alleged to

occur in Japan. The most important of these are as follows.

5.1.2 Economic incentives

Japanese government incentives for development of favored industries have already been outlined. There appears to be no fundamental reason why the United States should not consider adoption of similar methods in order to meet the demands of foreign competition. To summarize, major tools used by the Japanese have been the following:

1. Allowance of extra-accelerated depreciation and shorter terms for depreciation of capital equipment and R & D investments for industries which are either felt to be important to the country's economic growth or for which the government requires maintenance of a basic capability for strategic reasons;

2. Further tax incentives for firms engaged in export of their products in these favored industries;

3. Imposition of restrictions on foreign capital investment;

4. Encouragement of a high rate of personal savings;

5. Backing of low interest and/or guaranteed loans to preferred firms;

6. Maintenance of limited mobility of the best entrepreneurs, engineers and workers (through social as well as governmental pressures).

7. Direct or mandated procurement of the output of the emerging or renovated industry in its "infant" stages.

It is clear that the structure of American society does not condone limitations on personal mobility and employment. The idea of a lifetime job with a single company or government agency is considered ludicrous or, at best, anachronistic by many Americans. Nor is it at all clear that mobility limitations are even desirable in a rapidly evolving industry. A good argument can be made that the high rate of job shifting in the microelectronics industry is instrumental in the correspondingly high rate of technology transfer and development within the industry. However, there is no compelling reason why the United States government could not make a convincing case for industry-specific incentives such as the rest of the list just mentioned. The following are some of the instrumentalities for each of these potential alternatives. (These are summarized in Table 6-13).

Special Tax Incentives for Technology-Intensive Firms

This is an issue which is at the heart of the U.S. system of government. In general, Congress has been loath to grant special favors to a particular industry - and even less willing to aid individual firms - except in extreme circumstances, where major and immediately apparent economic disasters might occur. For, example, Congress has been persuaded to aid Lockheed and Chrysler primarily because of the high political visibility and concentrated effects of their forecasted failures, according to some analysts. The U.S. steel industry, on the other hand, while possibly in a decline ultimately as catastrophic as that projected for Chrysler, is dying slowly and relatively unobtrusively (due in no small measure to a chronic lack of innovation; which is due in turn, according to the American Iron & Steel Institute, to Federal economic policies, and to short sighted management

POLICY MAKING ORGANIZATION \ POSSIBLE IMPLEMENTATION Mechanism	DIRECT PROCUREMENT	MANDATED PROCUREMENT	RISK MITIGATION	LICENSING	Property Protection	TRAINING	TECHNICAL ASSISTANCE	EXCLUSIONS (TARIFFS, NTBS)	INFORMATION DISSEMINATION	COMMENTS
Executive Office of The President U.S. Trade Representative			x	x	x		x	x		Establishment of Trade Policy
U.S. Congress	X	X	X(R&D)			X	X	X	X	Budget Approval, Restrictions
		X	X	X	X			X		Regulatory, Patent, Copyright Legislation
Dept. of Commerce				X			X		X	Export Assistance
		X		X	X			X		Trade Treaty Enforcement, Tariffs
			X				X		X	Standards
			X			X	X		X	Trade Adjustment
Depts. of Defense, NASA, HHS	X	X	X				X	X	X	Procurement, R & D
				X	X					Patent, Copyright Licensing
						X				Personnel Training
Education						X			X	Computer Specialists, Computer Literacy
		X	X					X		School Support, R & D
Department of Justice			X		X					Limited Antitrust Exemptions For Technological Innovations
Treasury Dept. IRS			X							Corporate and Personal Tax Incentives
GSA	X	X	X							Market Stability Through Large Volume Steady Ordering
Patent Office Copyright Office					X					Software Protection
					X					
Small Business Admin.			X				X		X	Loans to Innovative Firms
			X				X		X	

TABLE 6-13

POLICY IMPLEMENTATION OPTIONS - INTERNATIONAL TRADE

practices, according to critics of the industry). But, because its demise is slow, there are as yet no similar heroic rescue measures circulating in Congress except through such measures as the Trade Adjustment Act. In any case there is certainly little sympathy for special tax incentives for an industry which is currently thriving.

One argument for special incentives is that the personal computer and related industries are faced with special problems, particularly those related to the dynamics of their growth. Unlike more mature industries in which the rate of technological change is slower and more stable, the personal computer and related industries are faced with obsolescence times of two or three years rather than decades. Further, as the hardware and software technologies grow rapidly more complex the rates of development, and the cost of "replacement" capital equipment, and the demands for development capital increase pace. The small firms currently typical of the personal computer industry may often be unable to take immediate advantage of powerful incentives such as the investment tax credit because the requirements for capital outlays in their developmental years may substantially exceed their profits. For these firms, a rebate on taxes yet unowed would be considerably more effective. Tax credit carry-forwards may come too late. Yet there is considerable hesitancy in Congress and among economists to engage in this form of up-front support.

Noyce points out that "over the last four years capital investment in plant and equipment as a percentage of sales has grown by sixty percent" (Noyce, 1980) and that the cumulative investment in plant and equipment in the microelectronics industry over the next decade would be about $28 billion, or about two-thirds of the projected annual sales at the end of this period. The personal computer industry is less capital intensive than the microelectronics industry (at present) but might be expected to have similar capital requirements for sustained growth over this period. If so, then the personal computer industry might be expected to require a cumulative investment of from $4 billion to $16 billion over the next decade, much of it in capital equipment requiring replacement by the end of the decade. Since the dominant mode of investment philosophy in the U.S. emphasizes a fast return on investment and is adverse to even moderate risk-taking it appears that some non-market means of enticing a greater level of investments in these technology incentive industries must be found. Tax incentives can provide these inducements while still keeping the actual investments in the private sector. They also have the political advantage of not requiring highly visible Federal expenditures in inflationary times. Boretsky, on the other hand, argues that past Federal Tax incentive actions, in and of themselves, appear to have had no effect on increasing growth in investment (Boretsky, 1980).

Export Tax Incentives

One form of taxation used in Japan and Western European countries is the manufacturing tax (or value added tax) imposed by the government on all manufactured goods. One means of government stimulation of export trade in these countries is through the reduction or elimination of this tax on exported goods. Since the United States does not have such a manufacturers tax, there is no direct parallel in provisions in this form of incentive. However, it would seem reasonable to include tax deductions or credits for export industries as part of the provisions of the Corporate Tax Laws.

The problem with enaction of measures of this nature is the same as that for specialized investment tax credits; justification of incentives for particular industries, or particular types of industrial activity, has been unsuccessful in the past. The general attitude of Congress toward stimulation

of export trade must, it seems, be modified if these incentives are to be passed.

Restrictions on Foreign Investment

As an example of one presumed threat, Table 6-14 shows some of the foreign ownership of some leading U.S. semiconductor and computer firms, including one (PERTEC) in the personal computer industry. To a significant extent these takeovers can be traced to a lack of suitable domestic alternatives for acquiring the capital needed to sustain the industry's growth rate.

As mentioned previously, one of the underlying reasons for the lack of domestic capital is the seemingly general aversion to risk taking on the part of major U.S. firms and venture capitalists (the Director of Contracts and Grants at the University of Southern California, for example, points out that he finis it much easier to negotiate grants for research support from Japanese than from U.S. firms. The Japanese are much less concerned with issues of patent rights, publication of research results, etc.) Although the Federal government cannot be expected to change basic attitudes of businessmen, a combination of risk reduction by the various methods discussed here, and limitation of foreign investment could produce the desired results.

There is, of course, debate among economists as to whether foreign investment should be discouraged. As with most issues of this type, the question ultimately is one of degree; whether foreign interests are liable to exert sufficient control over the activities of the firm, or extract an excessive amount of the benefits of the firm's activities, so as to constitute an undesirable influence.

All of these terms are quite vague and are the subject of considerable and continuous debate. The previous example of Japan can only be given as something to be considered. Traditionally the Japanese have strongly discouraged foreign investment in their industries. The only two computer companies which have had success in this regard have been IBM and Texas Instruments. However, restriction of foreign investment in U.S. firms without accompanying development of incentives for domestic investment would be self-defeating. Although the world pace of development would be slowed if American firms were not able to develop as fast as they have been, the world market's share attributable to U.S. firms would certainly decrease. In the meantime, as inflation continues to strengthen the emphasis on short term return on investment, the prospects for foreign acquisition of U.S. firms in the personal computer and related industries will increase.

Encouragement of Personal Savings

As mentioned earlier, a major source of capital for Japanese and European technology intensive firms is through debt financing based on personal savings. At the end of 1979 the ratio of personal savings to disposable personal income in the United States was down to 3.2%. Continuing inflation continues to erode even that low number. The ratio of personal savings to disposable income in Japan has also decreased recently but the decrease has been from a high of 23.7% in 1974 to about 21% in 1979; almost 7 times higher than the rate of savings in the United States. Since household savings typically furnish about 1/3 of the total capital investment based for the United States this is a critical fact. Even though there is some question as to the strict comparability of these two res, because of differing definitions and economic structures, the fact remains that favored Japanese firms seem to have readier access to debt capital than do U.S. firms.

TABLE 6-14

International Joint Ventures/Takeovers
In Microelectronics and Computer Industries

TYPE OF VENTURE	U.S. FIRM	FOREIGN FIRM/INTEREST
JOINT VENTURE	ANELVA	VARIAN/NIPPON
TAKEOVER	FAIRCHILD	SCHLUMBERGER ($305M, 1979)
JOINT VENTURE	GTE	INSAC (Viewdata)
TAKEOVER	SIGNETICS	U.S. Phillips
TAKEOVER	ADVANCED MICRO DEVICES	SIEMENS
PARTIAL TAKEOVER	AMERICAN MICROSYSTEMS	BOSCH
TAKEOVER	PERTEC	TRIUMPH-ADLER/(VOLKSWAGEN, DIEHL DATA SYSTEMS) ($117M, 1979)

Inflation seems to be the key to the declining U.S. savings. Expectations of prices rising faster than the interest rates on savings have caused many Americans to change their savings and spending habits in favor of consumption and to the detriment of savings. Clearly, control of inflation is a critical factor in increasing the rate of investment and savings. One incentive which has been quite successful in Japan is the set-aside from taxable income of the first $5,000 in savings or other investment interest, as compared with $200 in the U.S. If a similar measure were to be adopted in the United States, the savings income of most families would be exempt from income taxes, since few families have personal savings in excess of $50 thousand.

Loan Support

One of the primary means by which the Federal Government provides aid to business is through the support or granting of loans for business expansion, typically through such agencies as the Small Business Administration and Commerce's Economic Development Administration. In general, in these programs, the government is the lender of the last resort; firms are not eligible for direct Federal loans or for loan guarantees unless they have essentially exhausted all private sector alternatives. This, of course, is yet another example of Federal policy acting to ignore our strongest industries; that is, those who would be able to find private backing at some price, and protecting only our weakest and most failure-prone firms. If this government support were directed toward new, small, high-technology firms it could exert a quite positive influence, provided that the support were to be given in such a way as to maintain productivity. However, such is generally not the case. This is in contrast to the Japanese policy in which the government, although not in the practice of making direct loans, does have significant influence on the loan decisions of private banks. For example, the Japanese Ministry of International Trade and Industry moved early in 1980 to support the leasing of industrial robots to small- and medium-sized companies. This move was made as part of the overall plan to maximize Japanese industrial productivity through automation (Business Week, 9 June, 1980).

Procurement Policies

Finally, there are a variety of means by which the Federal Government can influence the growth of an industry through its procurement policy. There are two categories of procurement policy coming under this heading.

In the first, direct procurement, the Federal Government is the purchaser of the hardware and software. For example, if the General Services Administration and/or one or more agencies in the Executive Branch were to decide that personal computers would be more cost-effective in Federal offices than existing large computer equipment, time sharing systems, etc., and substantial procurement of personal computers were to result, the consequences would be a major stimulation of the industry. The author's experience with the current technology of "office automation" in Federal offices is that the Federal Government is several years behind the more innovative private sector firms in this respect. This is partially a consequence of a series of regulations restricting the purchase and use of computers in government. On the other hand, since these regulations tend to concentrate on large computer systems, many individuals within Federal agencies have resorted to the purchase and use of personal computers for routine office functions through various clever avoidances of the computer procurement rules [Note: this statement derives from the author's conversations with members of various

Federal agencies]. An overt decision by Federal agencies to purchase personal computers, rather than the covert methods currently being used by individual Federal employees, would clearly accelerate the rate of development of the industry.

The second means by which the government could strongly influence the market for personal computers would be through mandated procurement policies; i.e., those in which the Federal Government, although not the direct purchaser of personal computer hardware and software, would directly or indirectly require recipients of federal funds to purchase them. If defense contractors, for example, were required to demonstrate certain increases in the productivity of engineers, increases which might be achieved only through the widespread use of personal computers in the aerospace and defense industries, the effect on the personal computer industry would be substantial. Similarly, a requirement that the grantees of major educational grants were to use personal computers for administrative and/or instructional purposes as a condition for receiving grants, would have similar impact. In addition, a "buy American" requirement for policies such as the above would further restrict the benefits of such procurement policies to U.S. manufacturers and software producers, although at the risk of possible retaliatory actions by other governments.

The recent history of Federal procurement activities has shown that such policies are by no means universally popular. They would certainly be difficult to justify solely on the basis of guaranteeing the success of an emerging industry, as has been the case in Japan. However, if quantative research, as yet not performed, were to convincingly show that the use of personal computers in certain types of government operations, or in the educational system, etc., would have significant positive effects on net productivity, an argument for procurement policies of these sorts would likely be much more successful in Congress.

5.1.3 Direct Research and Development Support

There is already a considerable amount of support of basic research in semiconductor electronics by the Department of Defense, NASA, and the National Science Foundation. The Department of Defense is currently concentrating its efforts on the development of very high speed large scale integrated circuits (VHSLSI). Although it is estimated that there may be ultimate utility for these developments in the commercial sector, their main application is in very fast, large computers - not personal computers. One of the areas in which Japan has developed technical superiority to the United States is in improved reliability in the manufacture of microelectronic circuits and in the subsequent quality of the chips themselves. There does not appear to be extensive existing Federal support of research in this area.

It is in the area of software that the United States is currently relatively unchallenged, particularly in the personal computer industry and in applications and operating system software generally. However, it appears that the development of compact programs with high user interface "transparency" is vitally necessary to the continued development of the consumer computer industry. Problems of software availability for larger computer systems are already becoming significant, even for major corporations such as IBM. There is no reason to believe that these difficulties will be relatively less for the personal computer industry except in the short run.

As an example, one technological breakthrough which would greatly accelerate the rate of diffusion of personal computer technology would be development of compact voice encoding (as distinguished from voice synthesizer) software. In the ability to speak to one's computer rather than

type messages to it the Japanese (among others) are rumored to be close to development of an effective software capability. Since this capability could have significant impact on Federal operations, as well as on the private sector, it should be in the best interests of the government and industry if the Federal government were to support basic research in this area. The broader issue of the impending software bottleneck is touched upon in Section 5.1.4

These samples of R and D support needs are by no means restricted to personal computers. As with most of the other technologies discussed in this report, personal computers are often simply recipients of technological advances which may originally have been made for other industries, even though certain technological advances, such as voice encoding, may have far greater impact on the personal computer industry than on other elements of the computer industry.

A recommendation of growing popularity in connection with the President's drive to improve U.S. technological productivity and the rate of technological innovation has been the creation of generic technology centers. However, as these centers are presently conceived, at least in programs supported by the National Science Foundation, they tend to concentrate on basic rather than applied research. After examining the international situation for a while, one cannot help questioning our apparent general lack of Federal concern for applications of the vast amount of basic research we have already performed; applications which are steadily being developed by other countries such as Japan through the use of U.S.-produced basic research. In effect, in the view of many critics, the United States appears to have a de facto policy of concentrating on basic research, while allowing other countries to exploit it to our detriment. In this regard, it is important that at some least generic industrial technology centers (generally conceived as involving university /non-profit institution/ industry joint efforts) would concentrate on the development of applied technologies with relatively near-term production possibilities. This does not appear to be the present Federal trend. Federal agencies insist that applied research is a job for industry. Industry complains that it cannot afford the risks of applied research. In the meantime, some other country does it.

5.1.4 Training Support

As with the previously discussed modes of Federal influence in the development of the personal computer market, there are a variety of means by which the government can directly influence market growth. One of these is through government supported training (as contrasted with educational support discussed elsewhere). First, the Federal Government can train large numbers of military and civillian personnel both as users/operators and as maintenance personnel of personal computers. These decisions should accompany procurement policy decisions mentioned previously. The consequence would be a direct increase in the public sector of the base of trained computer users and technicians as well as a related increase in the private sector. The private sector increase would come about as a consequence of entry of trained military personnel into civilian life, secondary purchases of personal computers by Federal employees first exposed to them in the office environment, etc. In fact, because of the likely critical near term shortage of qualified computer maintenance personnel, the Federal Government could be a major source of such training, again provided that training programs were develdoped in consort with a procurement policy.

Furthermore, existing job training programs supported by the Department of Labor might be reoriented to emphasize training for jobs in

emerging, rather than dying industries. For a further discussion of this see Chapter 5.

Because of the rapid growth of the computer industry in general, and of the personal computer industry in particular, there will be enormous demands for highly trained skilled personnel for the development of computer hardware and particularly software and of the microelectronics fundamental to their development. As an example of the requirements, Figure 6-10 shows the projected increase in demand for design engineers as a consequence of the continued growth of the microelectronics industry. Specifically, the figure points out that, if the microelectronics industry is to grow in accordance with "Moore's Law" as it has for the past decade and a half, then the industry will need several hundred thousand design engineers by 1900 if engineering productivity is not somehow considerably increased. The figure also shows the current rate of production of "computer specialists" in the United States labor force. These data include all persons having to do with the design, maintenance, and/or operation of computers, not just computer design engineers. The figure shows that, if engineering productivity remains constant, then the demand for computer design engineers will outstrip the total supply of computer specialists in the United States in the early 90's. If this were to occur and the industry were to continue to grow it is obvious that the supply of design engineers would have to come from another country, such as Japan. The alternatives include:

1. An increased level of research and development directed toward increasing computer engineering productivity, such as the development of improved computer aided design (CAD) techniques.

2. A substantial increase in moral and/or financial support for students in computer applications and software engineering (required in a fairly short time if such a program is to be successful).

3. Acceleration of "brain drain" hiring of foreign trained computer specialists by U.S. firms.

4. Do nothing and allow the primary source of innovations in computer technology to shift to other countries, probably Japan and Western Europe.

Finally, through the Small Business Administration and various Department of Defense programs, the Federal Government could aid in the training of personnel in the private sector. As is the case with procurement policies, such training support could be either direct, through job training programs previously mentioned, or indirect through mandated requirements for personnel trained in the use of personal computers as part of government contracts and grants. Such training requirements need not be restricted to the technological applications. In fact, the economic leverage of personal computers may be much greater, in the short term, in their use in aiding management decisions, particularly in small businesses. Federal support of training programs in this area would likely have fairly high leverage.

5.1.5 Juridicial Barriers and Incentives

There are two areas in which Federal courts and the Department of Justice are said to have had, and will continue to have, significant influence on the rate of development of U.S. computer and other technologies. These are the treatment of patents and copyrights, and the enforcement of antitrust laws. The former set of issues relates to prior precedents and

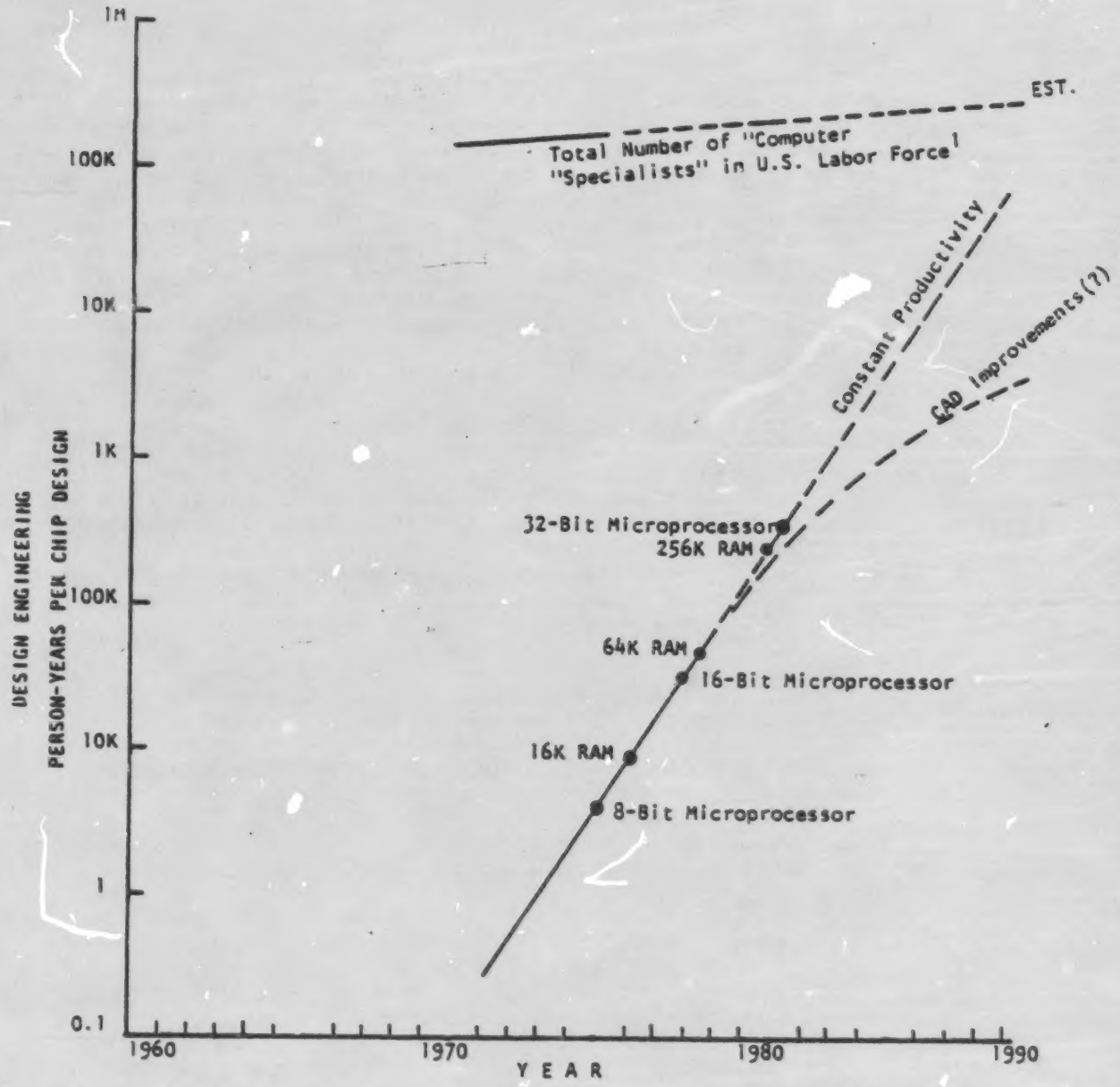


FIGURE 6-10 Microelectronics Industry Engineering Requirements[2]

1 Source: Science Indicators, 1978, Table 5-2

2 Source: Moore's Law; Science, 2 May 1980, p.483, JMN Calculations

interpretations of copyright and patent laws with respect to computers, microelectronics, and software. The second area relates to interpretation of the conditions under which the companies may combine to pool their development capabilities.

As discussed earlier, a major barrier to the more rapid development of quality computer software for mass distribution is said to have been an almost complete lack of legal protection of the software as intellectual property of its developers. A series of court decisions have essentially made it impossible to protect ordinary applications software that is embodied on materials such as magnetic discs and tapes.

A recent Federal court decision has extended that lack of protection to software embodied on ROMs, the most favored means of physical protection of the software. Similar uncertainties attend future protection of the layout of microelectronic chips under existing U.S. copyright Laws. CONTU recommendations for revision of U.S. copyright laws would substantially alleviate some of these problems, but as yet, such provisions have not been incorporated in the copyright Laws. Nor have Federal Courts been presided over by justices with adequate background in technology. Widespread training in computer technology of judges likely to be involved in patent and copyright cases would further enhance the stability of this aspect of the high-technology market. The most favored argument for these decisions seems to be that, since the software isn't copied in a form immediately readable by humans and is not otherwise covered by the copyright laws - as are phonograph recordings, it is not copyright. Similar uncertainties attend future protection of the layout of microelectronic chips under existing U.S. copyright and patent laws.

One of the major characteristics of Japanese industry is a high degree of cooperativeness between major firms in a particular industrial sector. Although these firms may compete vigorously for specific product areas, they also communicate and interact with each other extensively in the development of long-term plans. "The foreigner is struck with the paradox of extraordinarily competitive relations among firms in a single sector whose leaders nonetheless genuinely enjoy each other's company when working with the sector as a whole. Sector association leaders at times fight almost as arduously and effectively in the interest of the sector as a whole as the individual company leaders fight for the good of their own businesses. Indeed, they cannot understand how Americans can keep their individual companies abreast of modern developments without the kind of cooperation that American antitrust practice forbids." (Vogel, 1968).

As Vogel points out, such cooperation, which has been instrumental in the rapid development of Japanese international competition in microelectronics and computers, is expressly forbidden in the United States. Antitrust Laws written around the turn of the century to overcome unfair competitive practices of major corporations may, in this context at least, have outlived their usefulness. If it is true, as the evidence we have gathered thus far suggests, that the United States is approaching an era of a serious dearth of innovative talent, then it would appear to be an equally serious error to require potential continued wasteful duplication of effort among competing firms, or force U.S.-based firms to engage in joint research with firms from other countries, than to allow at least some level of intercorporate communication in order to help produce a more orderly development of the market. In some respects this problem is alleviated in the microelectronics industry by the high rate of flow of engineers, scientists, and technicians among competing firms. This amounts to an indirect form of intercorporate communication, if involuntary; a form which is not proscribed under antitrust laws.

5.1.6 Information Dissemination

The Federal Government may be the largest single publisher in the world. Its publication activities cover almost every aspect of contempory life (see Technology Assessment of Government Publishing, National Science Foundation).
Through the Government Printing Office, almost all Federal Agencies produce written documents to aid and inform a variety of individuals.
Federal information dissemination activities can help increase the U. S. position vis-a-vis international trade by a variety of means including the following:

1. Increasing the efficiency of R & D in the microcomputer industry via NTIS, NASA Industrial Applications Centers, and related activities

2. Development of information packages for small businesses explaining applications, drawbacks, selection criteria, etc., for personal computers

3. Dissemination of information concerning consumer uses of personal computers such as automated assistance in preparation of tax forms, health care information programs, etc., as well as information standards for consumer protection

5.1.7 Summary

In summary, there are a number of broad support alternatives commonly employed by other countries which have acted to rapidly increase their technological capability relative to that of the United States. In general, not only has the U.S. government failed to adopt many of these policies but it has specifically rejected many of them as being contrary to the de facto national policy of arms-length dealings between government and industry. It is not at all clear that the U.S. government can maintain this philosophy, if the United States is to maintain its technological leadership.

5.2 Trade Policy

In addition to the set of policy options related to the basic health of the personal computer and related industries, there are a set of issues and options dealing specifically with the process of international trade. These include:

1. The extent to which the United States should engage generally in, and act to enforce, free versus restricted international trade and intergovernmental cooperation;

2. The extent to which the Federal government should supply guidance and support to producers and distributors for increasing their export consciousness and their level of export activities;

3. The extent to which personal computers should be considered strategic goods;

4. The extent to which the U.S. should encourage or restrict foreign manufacturing of personal computers for U.S companies or by U.S.

companies;

5. The extent to which the U.S. should encourage or limit foreign production of software for U.S. companies or by U.S. companies; and

6. The extent to which the United States should encourage or restrict the exportation of U.S. services, "know-how," "brain drain."

Under the newly restructured Federal organization for international trade, most of the direct trade issues fall under the aegis of the U.S. Trade Representative and the Department of Commerce.

5.2.1. Free Trade Policies

As demonstrated earlier, the United States' philosophy has gradually changed over the past two hundred years from one encouraging highly restrictive trade to one encouraging free trade, particularly regarding the imposition of tariffs. Contemporary economic thinking applauds this attitude. The primary contemporary concern regarding free trade is that of insuring that all trading partners of the United States have an equal lack of barriers to free trade. The newly reorganized Federal international trade activity has as one of its major goals the enforcement of free trade agreements - as described earlier. From the narrow point of view of trade in personal computers, this is greatly to be desired, since it is clear that at present there is very little to hinder U.S. dominance of the market except artificial trade barriers.

5.2.2. Federal Support of U.S. Export Activities

A variety of activities of the USTR and the Department of Commerce come under this heading, under the newly implemented trade reorganization. First, the USTR is chartered to "take steps" to correct national policy so as to reduce impediments to exports and increase the effectiveness of exportation and of export opportunities. However, as mentioned earlier, it appears that the USTR is in the position of a non-cabinet level officer bargaining with cabinet members (Commerce, State, Treasury, Defense, and Justice). Although it would appear that - all other things being equal - the USTR is likely to have consequentially increased leverage in his/her negotiations, it is also clear that the intent of both the President and the enabling legislation is to have a materially increased emphasis on exploiting export opportunities.

From the direct economic point of view, the USTR is now a member of the board of the Export/Import Bank and a member of the National Advisory Committee on International Monetary and Financial Policies. The USTR will also become a voting member of the board of directors and vice chairman of the Overseas Private Investment Corporation. Negotiations during the development of the reorganization plan emphasize the mutual commitment of the director of the International Development Cooperation Agency, the USTR, and the director of OMB toward export expansion. However, the Senate report on the reorganization is heavily sprinkled with "help insure" statements in its description of the new roles of the USTR. The "help" modifier clearly means that the USTR will have far less than dictatorial powers over the activities of these agencies, a further indication that the dominant mode of the USTR will be that of Allison's bureaucratic politics.
(Allison, 1971)

One of the primary means of export promotion put forth by the reorganization plan involves the transfer of some 750 individuals to the

Commerce Department whose primary function will be the provision of business services abroad.
This transfer involves 160 commercial attaches in over 60 countries. The purpose of the transfer is both organizational and psychological. The supporters of the reorganization maintain that these positions, which were formerly under the State Department, have been considered relatively unprestigious. Consequently, one could expect that exceptionally qualified and ambitious bureaucrats would avoid them as barriers to their advancement. The move to the Commerce Department, with its emphasis on development of trade should lead to the development of an integrated and prestigous commercial corps encompassing domestic and foreign business services. If this transfer is accompanied by a corresponding shift in attitudes of the personnel involved, it can in fact lead to a significant increase in support services available to US firms wishing to export. This is still a far cry from the Japanese practice in which the elite bureaucrats of MITI are given intensive training and foreign assignments in order to develop long-standing relationships with businesses in other countries. As in the other areas of the reorganization, this is definitely a positive step toward countering competition from other developed countries, despite any present shortcomings it may have.

Since the personal computer industry presently consists largely of small manufacturing firms and small software houses, few of which can be expected to have much sophistication in international trade affairs, each of these recent changes in US trade policy and organization should have positive effects on the development of the industry. However, because it is equally probable that Japanese and, to a lesser extent, European efforts to gain a greater market share in this industry will continue and even accelerate, it is also clear that the effectiveness of these policies must be frequently reviewed and re-examined.

The question as to what constitutes "support" is also important in this context. As long as the industry is healthily growing and maintaining an appropriate share of the world market in personal computers, support most probably should consist of providing information to potential exporters which would allow their export efforts to be more efficient or toward formulating policies and practices which would tend to smooth the processing of export licenses, thereby minimizing the requirement for additional overhead costs to the manufacturers in coping with government regulations. This can be particularly important at the consumer computer level where the world market might be more volatile and "faddish" than would be the business and educational markets.

5.2.3 Personal Computers as a Strategic Good

Mainframe and minicomputers are high on the list of strategic goods. A number of regulations severely limits the extent to which computers may be exported directly to Communist bloc countries. The same or related regulations also limit re-export of computers, although it is not clear that these regulations are particularly effective. ("Re-export" refers to the process of ultimate shipment of computers and/or computer parts to Communist bloc countries through one or a series of middlemen.)

Personal computers have some interesting properties which may merit consideration of their status as strategic goods. First, because they are, or soon will be, suitable for performing a large portion of militarily useful routine computations, they can serve as the medium for rapidly upgrading the computational capability of military units in Communist bloc (or any other) countries. Second, because they are physically small and generally portable,

as well as relatively low in cost, the destruction of a few personal computers in the event of an enemy attack is less likely to severely impair the operations of a military unit than would the destruction of a larger computer upon which the unit might be dependent. Therefore, personal computers may be an important means of "hardening" against attack by virtue of their dispersion of otherwise centralized computing power. Third, because of the large numbers of personal computers likely to be in circulation over the next decade, it would appear to be extremely difficult in practice to limit their flow to western, non-Communist bloc nations. As was mentioned earlier, personal computers are already being shipped to at least one Communist country, the People's Republic of China.

Another scenario worth considering, one which was not included in our Delphi studies, concerns the potential of network-interconnected personal computers for the enhancement of personal freedom through their ability to assist in the formation and operation of ad hoc political networks. Because of its independence of geographical constraints, this concept could be a tool counter to totalitarian governments. However, it is difficult to see how this scenario could realistically be developed in the near future in any of the major Communist bloc or other countries with repressive governments. It appears to be much more likely that personal computers going to these countries would be absorbed by the military and scientific establishments and other "safe" government agencies with possession or use by ordinary citizens strictly prohibited.

5.2.4. Foreign Barriers to PC Exports

As a consequence of GATT and bi- and multinational trade negotiations, tariff barriers are less frequently used by other countries to stem undesired imports (countervailing duties). Under the provisions of the trade reorganization, administration of our fair trade laws and detection of unfair trade practices on the part of other countries has been transferred from Treasury to the Commerce Department. In addition to transferring existing positions from Treasury to Commerce, the reorganization provides one and a half times as many new positions for this purpose. It appears from past experience that non-tariff barriers (NTBs), such as import quotas and many other less obvious restrictions, constitute by far the more significant deterrent to U.S. exports. This was a major factor in the domination of the television industry by the Japanese, as reported earlier. Probably one of the major reasons for the shift from tariff to non-tariff barriers on the part of many countries is simply that non-tariff barriers are more difficult to detect since many of them need not be promulgated as official government policy but rather as "hints" to major importing concerns. Because of the great similarity, in many respects, of the personal computer industry to the consumer television industry, it is important that the existence of NTBs in major target countries be carefully monitored. It is of equal, and perhaps greater, importance that the reaction time of Federal agencies in developing countermeasures to these barriers be substantially reduced. It is completely unacceptable, in an area where annual market growth rates may be as high as 30% or 40% over extended periods of time, that government reactions to unfair trade practices take years.

Therefore, if national policy is to promote the development of personal computer exports, it is imperative that practices be developed for the effective reduction of any such barriers.

5.2.5. U.S. Barriers to Foreign Imports

Most foreign trade policy actions over the past decade, and the majority of statements made by leading economists on the subject of international trade discuss the development of free trade rather than U.S. protectionism. There appears to be no constituency in either the U.S. electronics, semiconductor, or personal computer industries toward the imposition of tariffs or non-tariff barriers against the importation of products in these industries manufactured in other countries. Our research team finds no reason to further consider policies which would act to develop or increase such barriers.

5.2.6 Offshore Production by U.S. Firms

A number of U.S. firms, particularly those in the semiconductor industry, have established manufacturing and/or assembly facilities in other countries, primarily in Asia, Mexico, and South America. The primary motivations for such moves were the decreased labor costs in those regions relative to the U.S. Other motivations may include a reduction in transportation costs where there are local markets for the finished products, or foreign government requirements that the products must be manufactured in their country if they are to be sold to the government or its citizens.

In recent years the labor costs in many of these countries have increased to the point where they are less important incentives for offshore production by U.S. firms. In fact, Noyce states that Intel has reduced the proportion of its foreign employees in recent years. Hence the attraction of offshore production as a means of increasing the size of the market in other countries has become the greater attraction. This may well be the case for firms in the personal computer industry in the future as they attempt to increase or maintain their share of the world market.

The primary Federal concerns with the development of offshore production are whether jobs, which might otherwise go to U.S. citizens, are being exported, and whether critical manufacturing know-how is being transferred to other countries as a consequence of this production. The alternative issue is whether U.S. firms would lose some of their share in the world or domestic markets if they were not to engage in offshore production. In general, it appears that offshore production by U.S. firms in the personal computer industry should be encouraged as long as the danger of undue technology transfer to the recipient country is minimized. There are a variety of existing tax incentives related to offshore production and/or the development of offshore sales corporations (Domestic International Sales Corporations - DISCs). No further incentives appear to be necessary at this point.

5.2.7 International Technology Transfer

As was frequently noted earlier, one important factor in the development of personal computer technology in the United States is that of maintenance of technological superiority, as embodied in the products of industry. Adherence to this principal would require that the transfer of U.S. developed technology to other countries be carefully monitored to ensure that the technology is not being sold at a price which ignores the long-term effects of such sales.

Again the issue of free trade arises. A major criticism of the actions of U.S. industry in recent years has been that it has failed to take advantage of native inventions, preferring to concentrate on incremental

product improvements than on development of new products. The inventions have then been licensed to foreign producers, subsequently appearing in the U.S. market.

The protectionist view of this situation would require that the transfer of U.S.-developed technology to other countries be stopped or, at least, carefully monitored and rationed to ensure that U.S. industry is protected.
They argue that presently U.S. technology is being sold at a prices which do not take into account the externalities such as the long term negative effects of such sales on decreasingly competitive U.S. industry.

One U.S. tax provision appears to act to encourage the rate at which U.S. technology is transferred to other countries. Specifically, the United States and the Philippines are the only countries which tax the personal income of their citizens earned abroad. The presumed effect of this on U.S. citizens with technological expertise is twofold: 1) a the expert living abroad would be motivated to seek employment with a non-U.S. firm since the likelihood would be high that the foreign employer would not report the income to the U.S. government; 2) U.S. technology intensive firms operating abroad would tend to discourage hiring of U.S. citizens in order to avoid the extra paperwork of reporting income to the U.S. government. In either case the result is that the technological expertise embodied in the U.S. citizen or firm is transferred more rapidly to potential foreign competitors. There are existing Federal restrictions on the transfer of technological information to foreign countries regarding the results of research and development programs supported by Federal funds. It does not appear that in practice these restrictions have been particularly effective in slowing the flow of information to the countries most likely to be serious competitors to the United States.

In general, contemporary economic theory favors free trade in ideas as well as goods and services. As with manufactured goods, however, the issue is whether free trade actually exists. In practice, for example, U.S. firms have adopted a free trade policy in providing technological information to Japanese firms. Japanese firms have not reciprocated these acts. The consequence is that the technology transfer has been unilateral, even in cases where other countries have had technologies of equal or superior quality to our own. Thus, the considerations mentioned in Section 5.2.4 are of equal, and possibly even greater importance as they relate to technology transfer.

One important characteristic of personal computers should be mentioned in terms of U.S. policy for aiding developing countries. Specifically, personal computers may be a much more appropriate technology than larger computers for the introduction of organizational methods and other "software technologies" to these countries. For example, recent purchases of personal computers by the People's Republic of China appeared to be in response to the requirement for the acquisition for relatively low-cost means for providing computer training to a large segment of the population (courses in programming languages are given prime time positions on government TV systems, according to media sources). As the powerful, low cost information tool, the personal computer may be a more important technological innovation in developing countries than in the developed countries.

5.2.8 Support to Import-Injured Industries

Aside from the issue of suppport of domestic industry, US foreign trade policy to date has tended to be reactive rather than anticipatory in nature. By far the largest amount of Federal economic support relating to foreign trade has been the Trade Adjustment program in which the government,

through the Departments of Commerce and Labor, acts to provide economic assistance to firms or labor unions which have already been injured by import competition. The rules of the Trade Adjustment Program require that the firm or union must have experienced absolute reductions in business or membership as a consequence of import competition; significant reductions in market share, unless accompanied by absolute reductions in income, for example, are not sufficient cause for Federal assistance. In practice, an import-injured firm must be close to bankruptcy before Federal assistance is warranted. This is in great contrast to Japanese practice where industries and firms which are not perceived by the government to have competitive promise are carefully weeded out and gently disbanded or absorbed into larger, more productive organizations.

6 Dynamics of Technological Development

The primary factors in the future development of the economic position of the U.S. relative to the rest of the world are as follows. We can expect U.S. agricultural production to count as a major contributor to our positive balance of payments. This contribution may maintain an essentially constant value, when adjustments are made for current (future) economic conditions. The focus of this wok, however, is on the general trends in R & D intensive products in general and on products related to personal computers in particular. As has been seen, U.S.-produced R & D intensive goods were a major part of our international balance of trade until the mid-1970's. Since that point, we have developed an increasingy negative balance of merchandise trade with West Germany and Japan. Our balance of merchandise trade has been about constant with developing nations since the mid-70's, even though those nations are presumably increasing total expenditures on technology intensive products. We conclude that the United States is achieving a decreasing market share for technology intensive goods in much of the world and that we are a net importer of technology intensive goods from West Germany and Japan.

The National Science Board points out that the United States is still a major world leader in the production of scientific papers, articles, and patents. That is, we are still the leading country in the exportation of technological knowledge. We have a positive balance of trade with all countries in technology transfer. Unfortunately, as the economic data seem to indicate, the primary economic gain comes from manufacture and sale of finished products, not from the knowledge of how to produce same. Although knowledge is a necessary condition for production of manufactured goods, it is by no means sufficient. Current systems of exchange, as practiced in the U.S., might be said to undervalue the know-how and overvalue of the finished goods. That, however, is small consolation to those who are watching our reddening international bank balance. Our positive balance of transferral technology is insufficient to offset the reclining negative balance in high-technology manufactured goods.

Even in the area of production of new knowledge, the United States is destined for a subsidiary role, if present trends continue. If we can assume that R & D productivity per dollar invested is relatively constant around the world (and it is by no means clear that R & D productivity is correctly as high as that of other developed countries) then the United States should expect to be in second or third place internationally by the turn of the century. This is a direct consequence of the fact that the non-defense investment in research and development in the United States is lagging behind that of its other principal competitors, particularly Japan and Germany. In 1975, according to the NBS (Science Indicators, 1978, p. 149) United States business enterprises spent $15.6 billion on R & D,West Germany spent 11.4

billion Marks, and Japan spent 1.652 trillion Yen in business-enterprise-supported research and development. That is, business expenditures for R & D in France, Japan, and West Germany in 1975 were above $5.5 billion in each country. Per capita R & D expenditures in 1975 by business enterprises were $74 in France; $51 in Japan; $34 in the United Kingdom; $73 in the U.S.; and $76 in West Germany. These figures do not include any influence on business spending of government-supported R & D; however, in Japan, there is very little government supported R & D (about $.90 per capita), while in West Germany and France government R & D spending is from one-half to two thirds that of the private sector (in the United States it is slightly more than one-half). Total expenditures by West Germany, the UK, Japan, and France in 1975 were $18.8 billion, as compared with $15.6 billion in the United States. For business-supported R & D or an average of $67.65 per capita for those four countries as compared with the $76.04 per capita in the United States. (All data from Table 1-8 of Science Indicators and various tables in the 1979 Statistical Abstract). In short, spending about 90% as much per capita on business oriented R & D in 1975 as was the United States. Since then, R & D expenditures in these countries seem to have been on a continual increase while that of the United States has been decreasing in constant dollar terms. Consequently, one could reasonably expect that in 1980 (or in the early 80's) the developed countries will have reached parity in business supported R & D. Furthermore, if these trends continue without alteration, we would expect the United States to shortly be in a secondary position relative to these other countries.

A further point should be made, one not covered by the available statistics. That is the contention that, within the United States, a fairly high fraction of what is called R & D in the aforementioned statistics is in fact product improvement rather than development of entirely new products. This is less the case in Japan and Western Europe, as is evidenced by the continued and increasing flow of innovative new products arriving in the United States from these countries. If this contention is true, then we might expect an even greater rate of erosion of the U.S. technological position with respect to the developed countries. [One might argue that this erosion rate would be slightly mitigated by the supposition that there must certainly be some duplication of effort in R & D activities among Japan and the Western European nations which might be higher than similar duplication among U.S. firms. However, this is a tenuous argument at best, since the competitive pressures of the marketplace would tend to minimize a continued large scale duplication over the long run. The correct status of the video-disc market, with several competing technologies from the U.S., Japan, France and the Netherlands demonstrates that the duplication exists. Similarly duplication will also exist in the personal computer market.

There is a further set of claims from industry that as much as 50% of the U.S. R & D dollar is spent on satisfying government reporting and environmental regulations (Source: [illegible] Till of Arthur D. Little as quoted in Electronics 1/17/80 p. 85). This figure presumably includes the amount of R & D which is spent on new technology directed solely to environmental quality applications; technology which is not necessarily exportable. The only regulatory constraints on personal computers relate to their use in data communications networks and their production of RF interference. Such problems as may exist seem solvable without a substantial R & D investment.

One of the primary difficulties in evaluating potential public policy options is that any options considered may be critically time dependent because of the extreme dynamism of personal computer and related technologies. It is important that the policy analyst consider the joint and sequential effects of 1) the rate of technological change, 2) the development of

societal impacts of the use of the technology, 3) the realization that an impact has occurred, 4) the translation of that realization into explicit policy decisions, 5) and the implementation of those decisions. If all of these are carried out in sequence, as is generally the case in U.S. government operations, then there may be a fairly significant chance that the policy actions will be taken only after the issue giving rise to them has ceased to become an issue, having been overtaken by events.

For example, in previous paragraphs it was argued that there is a distinct possibility that the United States will not produce sufficient engineering manpower to cope with the demand for microcomputer designers by the early 1990's. If the Federal Government were to directly support or successfully encourage programs for the accelerated training of such designers within the next two to three years, it is conceivable that the particular manpower crisis could be considerably reduced or averted. If, on the other hand, the government were to wait until definite proof was available that such a crisis indeed existed then it would not officially recognize the fact of such a crisis until from two to four years after its actuality, say in the mid 1990's. If an additional year were to be spent drafting appropriate legislation and if that legislation were to pass on the first try (an unlikely possibility) then the accelerated production of duly graduated computer experts would not reach full strength until sometime after the turn of the century. In the meantime, presumably, the production of suitably trained engineers by countries such as Japan, as a consequence of their current long-range plans in this area, would have been instrumental in the transfer of the innovative initiative to those countries. The United States might then find itself in a position of exporting its trained staff to other countries to find suitable jobs.

Unfortunately, we are, at this point, unable to assign quantative values to these speculations. Our experience leads us to believe that they are distinct possibilities but there are as yet no reliable data concerning actual demand and supply of existing scientific and technically trained personnel, to the level of detail required to make such predictions. One thing is clear, however: the typical generation cycle in the microelectronics industry is about 10 years and decreasing. The delay between development of a new technological capability and its widespread impact in use is about three years at most, since even moderately sophisticated users of microcomputers tend to anticipate future developments after a relatively short period of experience. The typical obsolesence periods for microcomputer equipment in nonconsumer use are about three years. Hence one could say that, in a period of from six to 10 years the entire microelectronics manufacturer and user complex could be transformed, with new or different combinations of manufacturers, replacing the original set. Hence, a legislative process taking 10 to 20 years to react to the perceived impact of the new technology could well be a generation behind by the time a legislative "fix" could be agreed upon.

7 Summary

There is no evidence at present that the personal computer industry is even close to being one which is liable to be adversely affected by competition from otr countries. On the other hand, past experience with other, once healthy industries in the United States gives us no assurance that the personal computer industry will be immune to such competition for any great length of time. Therefore, it is the opinion of the author that the Congress, the USTR, the Departments of Commerce, Justice, and Treasury (in particular the IRS), the National Science Foundation, and the Small Business

Administration, among others, actively consider the development of a coherent body of national policy which would include some of the aspects of Federal support of major industries while avoiding some of the errors which generally fall under the label of collusion between government and industry or which are not consonant with our societal structure.

Policy Analyses
International Trade

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APPENDIX A:

DELPHI QUESTIONNAIRES

THE FOLLOWING PAGES REPRODUCE THE ROUND II DELPHI QUESTIONNAIRES AS SENT TO THE PANELISTS, THEY DO NOT INCLUDE ALL RESPONSES BY THE PANELISTS Summaries of these responses are given in Chapter 3

SUMMARY DATA ON EVENTS

KEY:

The following are the results of the first round Delphi. The raw data are presented for the panel as a whole. These data, for example, may be shown as:

E	74	21	3	3	-
M	39	51	7	-	3
L	16	53	26	3	3
	80	81-84	85-90	>90	NEVER

Here: E = earliest; M = most likely; L = latest
The numbers indicate the percentage in each category;
- indicates none.
80, 81-84, 85-90, >90 and NEVER indicate the time period.

Two additional sets of data are shown where applicable.

E	[74]	21	3	3	-
M	[39]	51	7	-	3
L	16	[53]	26	3	3
	80	81-84	85-90	>90	NEVER

Here: the /////// indicates the median for those who rated themselves high expertise; the [ ] indicates consensus was considered achieved.

Note that in some cases, particularly those where market or technical questions are involved, we may accept the experts rather than the group as a whole for consensus.

Finally, to aid you in interpreting the results, we show you the number of respondents, N, and the number who rated themselves high expertise, H. Thus, for example,

N = 41 H = 13

implies 41 answered this question, of whom 13 rated themselves expert.

EVENT 1. A national retailer enters the PC market.

E	[74]	21	3	3	-
M	[39]	51	7	-	3
L	16	[53]	26	3	3
	80	81-84	85-90	>90	NEVER

N = 41 H = 13

EVENT 2. One of the manufacturers of large mainframes enters the PC market.

E	26	[59]	13	3	-
M	5	[61]	20	10	5
L	-	21	[45]	18	16

N = 41 H = 14

EVENT 3. Two large calculator companies enter the PC market.

E	[80]	20	-	-	-
M	[42]	54	5	-	-
L	13	[53]	29	3	3

N = 41 H = 19

EVENT 4. A major US company not now in the PC market enters the market.

E	24	[57]	10	3	-
M	5	[46]	37	10	2
L	3	18	[41]	23	15

N = 40 H = 6

EVENT 5. A 32-bit address register is introduced by one of four top PC manufacturers.

E	38	[62]	-	-	-
M	3	[61]	36	-	-
L	3	27	[49]	18	3

N = 40 N = 11

EVENT 6. A major foreign-owned corporation enters the PC mainframe market in US.

E	~~////~~	39		-	-
M	~~////~~	73	10	-	-
L	-	~~////~~	32	13	-

N = 41 N = 6

I. PARTICIPANTS IN THE MARKETPLACE

Events 1, 2, 3, 4 and 6 dealt with the possible entry of various participants into the marketplace. In general there was good agreement that these entries would occur early in the cycle, either by the end of 1980 or in the 81-84 period. There was less agreement on whether or when a CB-like craze for home computer entertainment would occur. Of 38 panelists who estimated latest occurrence, 12 indicated it might never happen.

Since the first questionnaire was issued, the following have occurred:

1. Sears is selling ATARI computers. Because of Sears' historical conservatism in introduction of new lines, this probably represents a long-term commitment, although the exact form of their marketing efforts may change.
2. Xerox has been added to the list of non-mainframe manufacturers who may enter the market. Such entry could, incidentally, be either with their own brand name or through acquisition of an existing manufacturer.
3. Hewlett-Packard has introduced their HP-85 Professional Personal Computer which, with Texas Instruments' TI 99/4, fulfills the condition that two major calculator manufacturers enter the market. The HP-41C programmable hand calculator-cum-printer is almost a personal computer by our definition, but is too restricted in application.

II. NETWORK INFORMATION SERVICES

The agreement on network information services questions was much less than on market questions. In particular, there were sizable groups who believed that neither polling nor revision of the 1934 Communications Act would ever occur.

In considering the network services, recognize that there are at least two firms currently offering commercial services directed to the personal computer user — MICRONET (Compuserve, Inc.) and The Source (Telecomputing Corporation of America). For purposes of EVENTS 8 and 9, do not consider these services to be events that satisfy the criterion since it is not clear at this time whether they are viable over the long-term. There are other indications of network service activity, including experiments by AT&T and trials, using a GTE-owned PDP-11 computer in Tampa, of the Viewdata system.

III. TECHNOLOGY

The purpose of the technology questions was to obtain a baseline check against the analysis which USC performed during the first phase of the project. We selected three developments: one in computer architecture, one in peripherals and one in concept of design.

To help you in the second round, the following are more detailed descriptions of these developments. Development of a 32-bit address register for personal computers implies that low-cost

main memory is available to the computer. The further implication is that personal computer applications requiring extensive memory access and probably using 16, 24, or 32-bit microprocessors, are possible for low-cost systems. Foremost among these application areas would be high quality, dynamic, color graphics, sophisticated direct voice input, and complex computer-assisted instruction programs. The question concerning commercialization of a low-cost flat screen deals with the issue of providing very low-cost consumer computers — at the $250 level or less. Development of a Dynabook-size personal computer, which essentially requires the existence of the previous two developments, connotes the arrival of the truly personal, easily portable computer.

IV. CRIME

Computer crime is a subject that fascinates many and which PCs may well exacerbate. We included four events in our general set of events; we also had a separate, detailed inquiry.

The first event postulated a law that would require registry of PC ownership. The concept was that there is an analogy between a computer-aided, white-collar crime and a weapon-aided burglary; both provide the criminal with leverage that s/he does not have without mechanical aid. Computer registration would thus, in a sense, be analogous to gun registration or to CB registration. The former has had considerable opposition, whereas the latter is done routinely. Such registration would aid both in detecting thefts of PCs and reducing the probability of such occurrences. If registration were to occur at all, it probably would not occur until 1985 or later, according to our panelists.

Two questions dealt with measures to protect software from piracy. We recognize the difficulty in defining what is "pirate-resistant." A simple criterion might be measures which, if implemented, would make the cost of pirated software equal to or close to the cost of honestly produced software. Such parity could be achieved by making software cheap (i.e., the marginal cost of the software would be small relative to the cost of the recording medium and packaging) thereby reducing the incentive to pirate, or by making piracy expensive via criminal statutes or tort law. Consequently, we have rephrased the question in this round.

One approach to protecting data and software is to provide encryption. Recent developments in encryption for large mainframes may well be transferrable to PCs at reasonable cost. A patent has been issued to Robert M. Best of Seattle, Washington, for a PC-oriented software encryption system; a cryptomicroprocessor. The question should be examined thus in the light of whether such transfer is feasible at reasonable cost and, if it is, whether it is likely to occur.

V. OTHER SOCIETAL ISSUES

These questions focus on two societal issues other than crime — privacy and equity.

The first event, enactment of legislation which makes PCs

subject to the Privacy Act of 1974 is based on the assumption that the widespread use of PCs will result in concern about the possibility of intruding into personal lives with these machines. The range of problems runs from the local boutique's maintaining credit and other information about customers to the transmission of malicious gossip over PC nets. The issues are complicated by the question of what constitutes private data; for example, must all people on a Christmas card list be notified they are on the list? The last might seem patently absurd, but stranger things have happened in the past. The Privacy Law of 1974, in brief, requires that Federal agencies make public the existence of data bases containing information about individuals, allow the affected individuals to examine the contents of files concerning them (with certain restrictions), and require correction of any errors found.

We do not show concensus on this question; however, there is clear indication that the panel felt that action was considerably down the road and that there is a strong possiblity that PCs may never come under privacy legislation.

The second event dealt with measures to provide PC access to the poor. It can be argued that if PCs become widespread, they provide information capabilities that would make it even more difficult for people with low incomes and little training to compete in the job market. A class of "information poor" might be created. One way of overcoming such class differentiations would be to provide public access to PCs. Our model is the availability of library facilities that provide access to books, magazines, records and, more recently in many places, to video recorders. The implication is that the public access PCs would also provide the opportunity to learn how to operate (and program) machines.

The opinion of the panel is that public access to PCs would occur only after widespread adoption of such subsidized use.

VI. APPLICATIONS

We sampled four applications areas for PCs:

- educational use; in particular, elementary school use;
- home monitoring
- government-mandated use; and
- energy conservation

In the case of educational software, the concensus was that such software was near at hand, within a year or two - and certainly in five years. There are indications that many firms are in the educational market; McGraw-Hill and other publishers are issuing books on the use of BASIC for specific PCs; EDS and other firms are marketing video tapes and other learning aids. Apple and Bell&Howell are entering the CAI market. Bills setting up personal computer projects in the Department of Education are being introduced. The Dallas School District is selling to other districts some of the courseware it developed for its TRS-80s. These activities indicate great interest in the educational market. The question asks whether this interest will translate into the widespread marketing of courseware for the elementary school level in particular.

The use of PCs for home monitoring is well established.- At present, it is usually a retrofit; in the future it might be reasonable to expect that PC-based monitoring would be built in to a house just as intercom systems and smoke detection systems are currently included in above-average cost homes. In framing our question, we chose a price of $100,000 as the cutoff in terms of 1978 dollars. A number of our respondents, particularly in Southern California, felt that this represented a very cheap house. Although the Southern California market has inflated, the median price of a new house nationally in 1978 was in the $60,000 range and even in Southern California was under $100,000. For purposes of answering this question, you may consider the $100,000 value to represent houses in the top quarter of those being built.

Our question on IRS requirements is based on conversations with the IRS that indicate that the IRS is presently considering such a move for the mid-to late-1980s. We seek the panel's view as to whether the agency will be able to meet such a goal. There may be institutional barriers within the government or lobbies outside the government that would either speed or delay such an action.

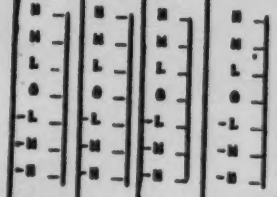
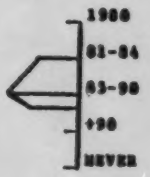
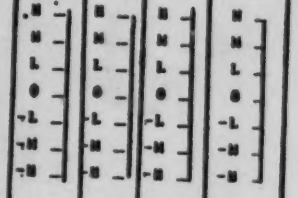
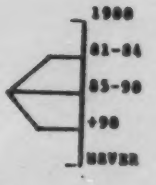
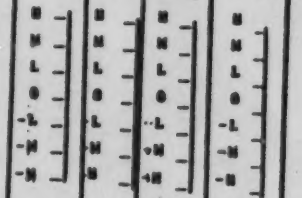
The substitution of communication for transportion has been discussed and researched since the 1960s. Do PCs combined with an energy-short environment, particularly rising gasoline costs or decreasing availability of fuel, provide technological and economic leverage to begin implementation of this concept?

PERSONAL COMPUTER EVENTS

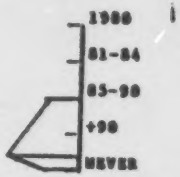
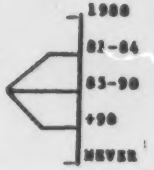
POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO: Home	Small Bus.	Large Bus.	Education	IMPACTS RESULTING FROM EVENT (economic, trade, workforce, regulatory, education)	EXPERTISE
I. PARTICIPANTS IN THE MARKETPLACE								
1. National retailer (e.g., Sears, Macys, Wards).	1988 / 81-84 / 85-90 / +90 / NEVER	+1 CB-like craze for PCs. +2 Availability of natural language software.* +3 PCs become upper end of calculator line. -1 Major recession or depression.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Computer store sales reduced. 2. New manufacturers enter mkt. 3. Foreign manufacturers enter mkt.	
2. One of the manufacturers of large mainframes (e.g. IBM, Control Data, Sperry Rand) enters PC mkt.	1988 / 81-84 / 85-90 / +90 / NEVER	+1 Opening of foreign mkts for PCs. +2 R&D breakthrough giving competitive edge. -1 Foreign competition. -2 Major recession or depression.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Shakeout of small manufacturers. 2. Entry of non-computer mfgr.	
3. A major US company not in computer manufacture (e.g. TYMNX, Westinghouse, Raytag, Xerox) enters PC market.	1988 / 81-84 / 85-90 / +90 / NEVER	+1 CB-like craze for PCs.						

*Software using natural language-like interface with user, not requring any programming ability.

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT (SALES TO)				IMPACTS RESULTING FROM EVENT (economic, trade, workforce, regulatory, education)	COMMENTS
			Home	Small Bus.	Large Bus.	Education		
4. A major foreign-based corporation (e.g. Japanese European) enters PC mkt in US for complete units.	1980 81-84 85-90 +90 NEVER	+1 A CB-like craze for PCs. +2 US firms fail to meet mkt demand. +3 Value of dollar increases relative to common mkt, Japan. -1 Import restrictions imposed by US.	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –		
18. A CB-like craze for computer entertainment occurs.	1980 81-84 85-90 +90 NEVER	+1 Availability of natural language software.* -1 General revolt against technology.	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –	H – M – L – 0 – -L – -M – -H –	1. Nat'l retailer enters mkt. 2. Non-computer mfgr. enters mkt. 3. Foreign competitors enter US market. 4. Major price break. 5. Increased number of people who program. 6. Push to standardization.	
		*Software using a natural language-like interface with user, not requiring any programming ability.						

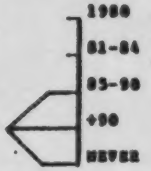
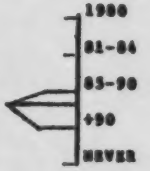
POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON BASES TO: Home	Small Bus.	Large Bus.	Education	IMPACTS REQUIRING FROM INDUSTRY (economic, trade, workforce, regulatory, education)	EXPERTS
II. NETWORK INFORMATION SERVICES								
8. A commercial firm develops and successfully markets a low-cost computer-based network information service for PCs.		+1 Entry of AT&T into the computer information services market. -1 Stringent privacy law for PCs. -2 Limited voice and data entry to networks.					1. PC networks used for polling. 2. Passage of privacy legislation. 3. De facto standards for conferencing with PC. 4. Situational net for training handicapped.	
9. Establishment of nat'l commercial information retrieval network for PCs such as Viewdata.		+1 Success of The Source & MICRONET. +2 Success of AT&T & others in current information experiments via cable. -1 High cost of local loop communications. -2 Limited, slow search capability.					1. CB-like craze for PCs.	
12. Establishment of a network of PCs in a community or region capable of polling voters.		+1 Success of computer conferencing for PCs. +2 Establishment of nat'l Viewdata system for PCs. +3 Successful experiments using cable TV for polling. +4 Use of PCs for Nielsen ratings or consumer wiz panels.					1. Privacy legislation to preserve secrecy of ballot.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OR VALUE TO				FORCES SHAPING	EXPERTISE
			Mfrs	Small Bus.	Large Bus.	Education	FROM ABOVE (economic, trade, workforce, regulatory, education)	
19. Revision of 1934 Communication Act to permit AT&T to compete in information services industry.	1980 81-84 85-90 +90 NEVER	+1 Divestiture of Western Electric by AT&T. +2 Entry of foreign phone company in US market. -1 Congress (or FCC) rules for computer-communications separation in common carrier industry.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Establishment of low-cost conferencing net. 2. High tariffs for conferencing.	
III. TECHNOLOGY 5. A 32-bit minus register is introduced for PCs by one of the top 4 PC producers.	1980 81-84 85-90 +90 NEVER	+1 Breakthrough in memory technology to reduce memory cost.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased data handling capabilities for business PCs. 2. Low cost, sophisticated OAI software developed.	
17. Commercialization of a low cost (<$50 to produce) flat screen for TV.	1980 81-84 85-90 +90 NEVER	+1 Development of flat screen technology for custom applications (e.g. commercial displays) -1 Development of alternative display technique at low cost such as cheap projection methods.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Cost reduction in price sensitive consumer mkt.	

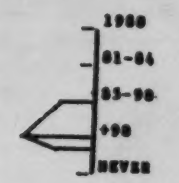
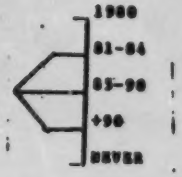
POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OR SALES TO				IMPACTS RESULTING FROM EVENT (economic, trade, workforce, regulatory, education)
			Home	Small Bus.	Large Bus.	Education	
25. A Dymo-like-size and capability PC is introduced.		+1 Occurrence of above two technology events. -1 Abandonment of the concept by Xerox.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase in applications of PCs requiring portability of unit.
IV. CRIME 7. Passage of law requiring registry of PC ownership just as BCC requires registration of CB radios.		+1 Passage of nat'l gun registration law. +2 A wave of thefts of PCs. +3 A wave of white-collar crime involving PCs coupled with media score publicity.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	2. Reduction of number of crimes using PCs.
13. Development of software or hardware other than ROM to make PC software effectively pirate-resistant.		+1 Encryption marketed for PCs (see EXHIBIT 24 below). -1 Development of disassemblers which convert machine language to BASIC. -2 Development of non-technological methods (see EXHIBIT 14).	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Reduced emphasis on non-technological methods. 2. Increase in software costs. 3. Increase in hardware costs. 4. Reduction(elimination?) of piracy.

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OF EVENT IF: Does	Small Bus.	Large Bus.	Education	IMPACTS RESULTING FROM EVENT (economic, trade, workforce, regulatory, education)
14. Establishment of measures (institutional, organizational, or contractual) that effectively make PC software resistant.	1988 81-84 85-90 +90 NEVER	+1 Congress passes stronger copyright law. +2 Formation of association of software producers. -1 Escalation of software costs in real dollar terms. -2 Development of technological methods (see EVENT 13).	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Elimination of encryption hackers. 2. Reduction of software piracy.
24. First commercialization of "break-proof" encryption cable for PCs.	1988 81-84 85-90 +90 NEVER	+1 Extensive software piracy. +2 Extensive theft of data from PCs. +3 PCs come under Privacy Act. -1 Encryption outlawed for reasons of national security.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Reduction in crimes using PCs. 2. Increased privacy. 3. Extension of privacy law to PCs less likely.

NOTE: Note that last column asks for "Impact on significance of crimes committed using PCs, as a societal problem." (TREND 29).

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OF RULES TO: Home	Small Bus.	Large Bus.	Education	IMPACTS RESULTING FROM EVENT (economic, trade, workforce, regulatory, education)	EXPERTISE
V. OTHER SOCIETAL ISSUES								
15. Enactment of Federal legislation that makes home PCs subject to Privacy Act of 1974.		+1 A privacy "scare" in the media. -1 Court ruling that PCs are already covered by Privacy Act. -2 Development of encryption modules for PCs.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Number of PCs involved in network activities.	
16. Establishment of direct gov't subsidy for PC access for low income people (e.g, through libraries, churches, or other public centers).		+1 High displacement of unskilled labor by PCs. +2 Increased substitution of communications for transportation of clerical workers.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase in computer literacy. 2. Increased decentralization of office activities.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OF RULES TO				IMPACTS RESULTING FROM RULES (economic, trade, workforce, regulatory, education)	EXPERTISE
			Home	Small Bus.	Large Bus.	Education		
VI. APPLICATIONS								
30. Initial marketing of PC courseware for elementary school instruction by major publisher or computer industry firm.	1980 81-84 85-90 +90 NEVER	+1 Successful marketing by current user school districts to other districts. +2 Federally sponsored courseware development. +3 Adoption of PCs by major state board of education as a recommended teaching tool. +4 A definitive study shows PCs have high value for gifted or special students. -1 A definitive study shows costs of PCs exceed benefits that can be obtained.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased computer literacy. 2. Reduction in need for teachers. 3. Massive retraining of teachers. 4. Increased math skills.	
31. At least 50% of all homes built in a year for $100,000 or more (1979 prices) include a dedicated PC for computer monitoring.	1980 81-84 85-90 +90 NEVER	+1 Commercial introduction of such a monitoring system. -1 Legal liabilities of error by such a system not covered by insurance companies.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Improved energy efficiency of houses. 2. Reduced burglaries. 3. Reduced fire damage.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT OR VALUE TO Home	Small Bus.	Large Bus.	Education	IMPACTS RESULTING FROM HURT (economic, trade, workforce, regulatory, education)	EXPERTISE
22. IRS requires that income taxes for all businesses with at least $1 million (1979 dollars) annual sales be submitted in machine-readable form.		+1 IRS makes available or approves computer programs needed for returns. +2 Development of low-cost PC software & low-cost storage for small business record keeping.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased Federal revenue. 2. More sophisticated computer crime for tax avoidance.	
23. Chronic gasoline shortages cause at least 10 of Fortune 500 companies to set up local work centers using PCs and telecommunications for information transfer.		+1 Low-cost PC nets available. +2 Increasing shortage of secretarially skilled workers. +3 Cheap local loop communications available for data transmissions. -1 Shortage of phone lines and/or premium costs for data usage.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Decreasing downtown real estate values. 2. Reduced energy use for transportation. 3. Changed urban structure; emphasis on regional work/shopping centers.	

TRENDS

SECOND ROUND

In the first round of the DELPHI you were asked to estimate the values of certain trends for 1985 and 1990. In addition, the curve representing the most likely pattern of change for each trend was given. The following pages present the results of these inquiries. In general, there was good agreement on the DIRECTION of trends, but wide dispersion on the values various trends would reach by 1990. Thus, we would like to have our panel of experts examine the results from the first round and provide a second set of estimates based on this and other new information.

For each trend, we show the forecasts for 1985 and 1990 made by those members of the panel who felt they had either medium or high expertise in the area. These forecasts are shown in terms of three values:

L = "low" estimate - at most one fourth of the panelists gave values below this estimate (25th percentile)

M = median estimate - half the panelists gave values below and half gave values above this estimate

H = "high" estimate - at most one fourth of the panelists gave values above this estimate (75th percentile)

L, M, and H values are also given for 1978 where values were supplied by the panel.

The curve column shows the curve indicated by the data by plotting the median values for 1978, 1985, and 1990. The key for the curves is given at the end of the trend section.

INSTRUCTIONS:

After reviewing the results, we would like you to do the following:

1. In the space provided, give your SINGLE BEST estimate for 1985, 1990, and the appropriate curve for the direction of change.

2. If your estimate for the best value is outside the range indicated by the L, M, and H values, or you believe a different curve than the one given is appropriate, please explain your answer briefly in the space

provided. The purpose of asking you to do this is not to justify your answer but to give us the benefit of the specialized knowledge and information that you have that neither we nor other panelists might have. These reasons are very important to us and your help is appreciated.

3. Finally, please record your level of expertise on each question. (Use L for low expertise, M for medium expertise, and H for high expertise.) If you feel you do not have enough knowledge to give an informed answer, do not hesitate to leave a question blank.

NOTE: ALL DOLLAR VALUES ARE 1979.
PLEASE BE SURE TO READ THE INSTRUCTION PAGE BEFORE PROCEEDING.

1. Cost of a PC with the capabilities of an Apple II with 16K of RAM (dollars).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
$1200	L=600 M=600 H=800	L=200 M=300 H=600	F					

1A. Cost of a PC with the capabilities of an entry level consumer computer (dollars). This is a new question, not asked in the first round.

1985	1990	curve	expertise

2. Total annual sales (number of units) of PCs.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
225K	L= 1M M=1.25M H= 5M	L= 2M M= 5M H=10M *	C					

3. Annual sales (number of units) of PCs costing under $5,000 to small businesses (100 or fewer employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=20K M=30K H=75K	L=100K M=225K H= 1M	L=200K * M= 1M H= 2M	C					

Note: M = million; K = thousand

4. Annual sales (number of units) of PCs costing over $5,000 to small businesses (100 or fewer employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=10K M=15K H=25K	L=12K M=60K H=150K	L=15K M=75K H=600K	A,B					

5. Annual sales (number of units) of PCs costing less than $5,000 to large businesses or governmental organizations (over 100 employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=25K M=25K H=25K	L=150K M=200K H=300K	L=250K M=500K H= 1M	C					

6. Annual sales (number of units) of PCs costing over $5,000 to large businesses or governmental organizations (over 100 employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L= 5K M=15K H=35K	L=40K M=100K H=150K	L=50K M=200K H=300K	B,C					

7. Number of PCs used in elementary and secondary education for administration or instruction.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
500 to 10K	L=60K M=100K H=250K	L=200K M=600K H= 1M	C					

8. Number of people who can program (in BASIC or more advanced computer language).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
5M (est)	L= 8M M=10M H=15M	L=15M M=20M H=30M	C					

9. Total cumulative number of new jobs created by PC industry and by industries created by PCs.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L= 5K M=10K H=20K	L=60K M=200K H=300K	L=60K M=300K H=500K	A,B					

10. Number of homes that can be reached directly by electronic mail.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
insig-nifi-cant	L=800K M=4.5M H=10M	L= 2M M=10M H=30M	B,C					

11. Percent of what is now first class business mail that is sent to PCs as destination.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
0%	L= 2% M= 3% H=10%	L=10% M=20% H=30%	C					

12. Number of people who use PCs (with perhaps communications) to reduce or eliminate their daily trip to work.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
insig-nifi-cant	L=100K M=500K H=7.7M	L=300K M= 1M H=19M	B,C					

13. Number of homes using PCs or dedicated microprocessors for routine health monitoring.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
none	L=50K M=500K H=1.5M	L=100K M=600K H= 5M	A					

14. Number of PCs exported by the U.S.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
20K	L=250K M=750K H= 1M	L=200K M= 1M H= 5M	A					

15. Number of PCs imported by the U.S.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
0	L=100K M=200K H=250K	L=300K M= 1M H= 1M	C					

16. Cost in dollars of a quality payroll program (note this question is a surrogate for the future direction of software costs).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
$500	L=250 M=400 H=600	L=100 M=200 H=600	E					

17. PC end user cost per megabyte of volatile storage.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
$15K	L= 2K M= 5K H= 8K	L=600 M= 1K H= 3K	F,G					

18. PC end user cost of 500x500 element displays.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
$10K	L=2.5K M= 3K H= 5K	L=600 M=800 H= 2K	G					

19. PC end user cost of modems.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
$150	L=45 M=75 H=90	L=20 M=25 H=30	F					

20. Number of retail outlets for PCs (includes dealers, department stores, text book stores on campus, etc.) (1978: 1,000 independents, 7,000 Radio Shacks, 200 others).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
8.2K	L=15K M=18K H=30K	L=20K M=30K H=60K	B,C					

21. Annual dollar sales of PC software to home users.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$1M M=$1M H=$2.5M	L=15M M=20M H=100M	L=20M M=100M H=400M	C					

22. Annual dollar sales of software to small businesses (less than 100 employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$1M	L= 5M	L=20M						
M=$2M	M=25M	M=50M	B,C					
H=$10M	H=200M	H=350M						

23. Annual dollar sales of PC software to large businesses (or government) (over 100 employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$10K	L= 2M	L=10M						
M=$1M	M=15M	M=30M	B,C					
H=$2.5M	H=50M	H=250M						

24. Annual dollar sales of software to primary or secondary educational institutions.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$20K	L= 2M	L= 8M						
M=$50K	M= 5M	M=18M	C					
H=$200K	H=15M	H=50M						

25. Annual dollar sales of computer interactive network information services to home users.

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$0	L= 1M	L= 5M						
M=$0	M=10M	M=50M	C					
H=$10K	H=25M	H=250M						

26. Annual dollar sales of computer interactive network services to small businesses (under 100 employees).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$500K	L= 2M	L=7.5M						
M=$1M	M= 5M	M=15M	C					
H=$1M	H=50M	H=200M						

27. Annual dollar sales of computer interactive network services to large businesses or government (over 100 employees).

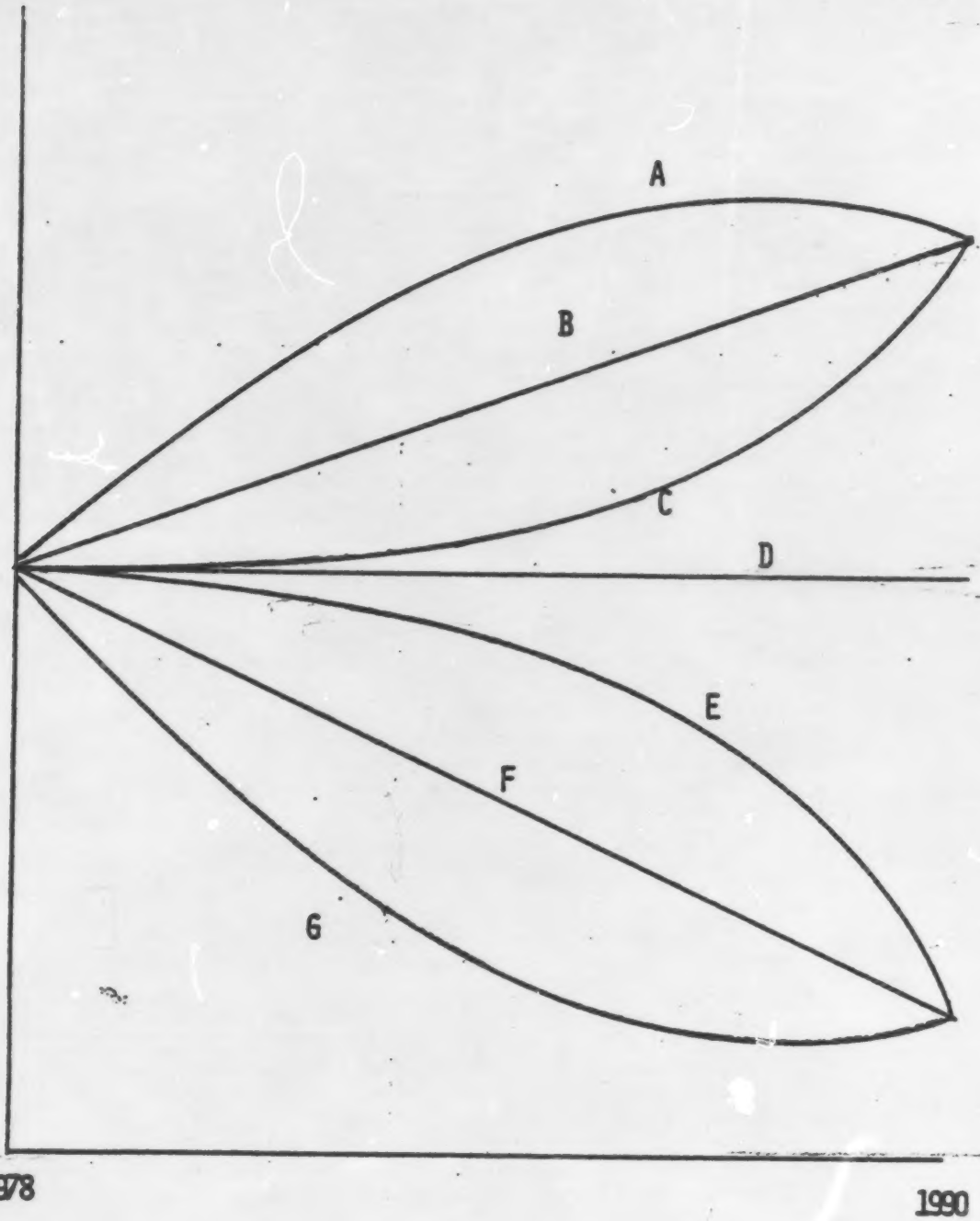
First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$1M	L=10M	L=50M						
M=$10M	M=75M	M=100M	A					
H=$100M	H=600M	H=700M						

28. Annual dollar sales of computer interactive network services to primary or secondary educational institutions (including PLATO).

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
L=$100K M=$5M H=$20M	L= 3M M=10M H=35M	L=10M M=20M H=40M	C					

29. Significance of crimes committed using PCs as a societal problem (index scale: assume 1979=1. Thus, if you feel that PC related crimes will be twice as much of a societal problem in 1985, than you would write in a score of 2. If PC crimes will be 10 times as significant, you would write a score of 10. Notice there is no upper limit; you may feel that the significance of crimes committed using PCs will be 100 times that of 1979 (or even more) in 1985 or 1990.)

First round estimates				Your current estimates				Explanation if outside given range
1978	1985	1990	curve	1985	1990	curve	expertise	
1	L= 1 M= 2 H= 3	L= 1 M= 3 H= 5	B					


A
B
C
D
E
F
G
1978
1990

THE PERSONAL COMPUTER AND EDUCATION

INTRODUCTION

Discussion of Round 1 Results.

The first round Delphi presented five scenarios for potential impacts of personal computers in education. The panel of twenty was asked to estimate the most likely time that each scenario would be implemented. Following the five scenarios were related questions on four issue areas (shape of educational market, institutional arrangement for obtaining PC courseware, mode of PC installation and market penetration) as well as a section of events, culled from the scenarios, whose most likely time of occurrence the panel was asked to estimate.

The results can be summarized by stating that the panel agreed that:

- Between 1985-90, PCs will be in regular use by at least 10 % of all students enrolled in public primary and secondary education in the US.
- Between 1985-90, PCs used in industrial production operations will be commonly used to perform on-the-job training and retraining of employees.
- Homes will ultimately be the largest purchaser of PCs for educational purposes.

A majority of panelists also agreed that the following events would NEVER happen:

- State compulsory education laws are overturned.
- Teacher lobbying against mechanical aids to teaching is successful.
- Federal government withdraws funding from educational technology as part of general cost reduction.
- Need for heavy duty construction of PCs to cope with hard usage by children drives prices out of reach of school districts.

The panel was divided (50% or less) on estimates for when the following scenario events will occur:

- 10% of all primary and secondary school age children will be using PCs either in private schools/centers or at homes.
- PCs will replace cassette recorders in the home study market.

In general, the overall implication was that PCs will definitely infiltrate the educational process, whether it be the formal educational system or industrial training, and that the Federal government has the opportunity to play a variety of roles, both positive and negative.

SUMMARY OF RESULTS ON EDUCATION SCENARIOS

	TIME OF OCCURRENCE				
	1980	81-84	85-90	+ 90	NEVER

1. PCs are in regular use by at least 10% of all students enrolled in public primary and secondary education in the US.

E	3/20	11/20	6/20	-	-
M	-	5/20	13/20	2/20	-
L	-	3/20	8/20	9/20	-

2. 10% of all primary and secondary school age students will be using PCs either in private schools/centers or at home.

E	5/20	8/20	4/20	2/20	-
M	-	5/20	9/20	4/20	-
L	-	2/20	7/20	9/20	-

3. PCs commonly used in physical education programs.

E	-	7/20	7/20	4/20	-
M	-	-	7/20	11/20	2/20
L	-	-	3/20	15/20	-

4. PCs replace cassette recorders in the home study market.

E	4/20	11/20	4/20	-	-
M	-	7/20	10/20	2/20	1/20
L	-	3/20	9/20	7/20	-

5. PCs used industrial production operations will be commonly used to perform on-the-job training and retraining of employees.

E	5/20	14/20	1/20	-	-
M	2/20	4/20	13/20	1/20	-
L	-	2/20	8/20	10/20	-

ISSUE AREAS

A. Shape of Educational Market

Results of Round 1:

PERCENTAGE OF PERSONAL COMPUTERS BOUGHT PRINCIPALLY FOR EDUCATION THAT ARE PURCHASED BY:		PERCENTAGE OF DOLLAR EXPENDITURES ON EDUCATION COURSEWARE BY:	
Primary Schools	10%	Primary Schools	8%
Secondary Schools	16%	Secondary Schools	19%
Home	23%	Home	17%
Industry (in-plant)	17%	Industry (in-plant)	18%
Commercial Training Institutes	7%	Commercial Training Institutes	6%
Community Colleges and Adult Educational Facilities	3%	Community Colleges and Adult Educational Facilities	9%
University-based Continuing Ed.	4%	University-based Continuing Ed.	5%
Department of Defense	15%	Department of Defense	18%
TOTAL	100%	TOTAL	100%

For Round 2, please give your estimate of the market percentages if they disagree with the results of Round 1. Note that universities and colleges are now included with university-based continuing education.

PERCENTAGE OF PERSONAL COMPUTERS BOUGHT PRINCIPALLY FOR EDUCATION THAT ARE PURCHASED BY:		PERCENTAGE OF DOLLAR EXPENDITURE ON EDUCATIONAL COURSEWARE:	
Primary Schools	____%	Primary Schools	____%
Secondary Schools	____%	Secondary Schools	____%
Home	____%	Home	____%
Industry (in-plant)	____%	Industry (in-plant)	____%
Commercial Training Institutes	____%	Commercial Training Institutes	____%
Community Colleges and Adult Educational Facilities	____%	Community Colleges and Adult Educational Facilities	____%
Universities, Colleges and University-based Continuing Ed.	____%	Universities, Colleges and University-based Continuing Ed.	____%
Department of Defense	____%	Department of Defense	____%
TOTAL	____%	TOTAL	____%

B. Institutional Arrangement for Obtaining PC Courseware

	NONE	SOME (<10% students)	MANY (10-60% students)	MOST (>60% of students)
Schools purchase and provide software to all students at no cost.				X 50%
Students purchase their own software; lending libraries provide for underprivileged.		X 45%		
Students are allowed to take software home.				X 50%
Other arrangements (please describe)				
1)Teacher/student creats.			X 25%	

C. Mode of Installation

	CHECK INSTALLATION MODE
One or two PCs per classroom	X 30%
One classroom with full PCs	
Neither	
Both	X 35%

D. Market Penetration

Of those panalists who responded, 100% agreed that adoption of PCs by educational institutions will be slower than adoption and diffusion of PCs in homes and business, due to the basic conservatism and inertia that exits in the educational field.

EVENTS QUESTIONS	E	M	L
Experimental assessment of value of computers for slow learners completed.	82	84	87
Experimental assessment of value of PCs for gifted children completed.	83	86	97
Development of extensive PC software for slow and/or gifted children using Federal funding.	82	84	88
Department of Defense routinely uses PCs for personnel training in basic skills and specialized tasks.	83	86	87
Installation of at least 10,000 PCs in schools using Federal matching funds.	83	86	87
Training in the use of PCs available for teachers in at least 10 schools of education.	82	83	85
Computer literacy questions appear on the SATs.	83	86	88
One of the 10 largest states requires demonstrated ability to operate a terminal as a condition for high school graduation.	85	87	90
High quality PC software becomes available for 25 different high school courses, including those normally required for graduation.	85	88	92
Federal court decision allows PC-assisted home training for children.	84	87	93

State compulsory education laws are overturned.		NEVER	
PCs for use in physical education are marketed successfully.	85	90	94
PCs are used in conjunction with videotaped lectures for continuing education credit courses for home use by a major college or university.	82	84	88
PCs are used in conjunction with videotaped lectures for continuing education credit corses for home use by a large vocational training institute.	81	84	87
10,000 PCs used in production operations are provided with educational software for on-the-job training.	83	86	90
Teacher lobbying against mechanical aids to teaching is successful Objective: maximizing teaching jobs.		NEVER	
Federal finds made available for PCs in schools for use by handicapped, disadvantaged.	82	84	87
Federal goverment withdraws from educational technology as part of general cost reduction.		NEVER	
Need for heavy duty contruction of PCs to cope with hard usage by children drives prices out of reach of school districts.		NEVER	

A CONSERVATIVE SCENARIO

The following scenario argues an extreme, yet plausible, position with respect to computers in education. After reading it, you will be asked to examine four counter arguments, add two of your own and rate all of them.

Many proponents of the potential of computers in the educational environment, and personal computers in particular, argue that computers will have the greatest impact on education since the invention of books, that they are a positive answer to the widespread dissatisfaction with today's educational system, and that the possible applications of computers in education are almost limitless. There is, however, no reason to believe that computers will affect the educational system to any significant extent; that is, they are not likely to have any more impact than educational television or programmed instruction or any other educational medium.

Since Socrates, it has been general accepted that there are three sine qua non's of education. First: students and information are required to be in the same place at the same time. In all but an insignificant portion of the educational enterprise, there has been no conclusive evidence to show that the method or medium by which this information is taught to the student makes any substantial difference in the amount of information learned. Also implied here is the "readiness" phenomenon; that is, a child's arrival at the appropriate psychological level allows certain skills or concepts to be taught which at an earlier level could not have been. Our educational system has incorporated readiness into the curriculum in that appropriate tasks, skills and concepts are introduced at appropriate levels. In other words, it is highly unlikely that a four-year-old child can be taught creative writing, no matter what method or medium is used.

Second: motivation to learn is the greatest single factor in the amount learned. The school system attempts to enhance the motivation that exists in students as best it can, but there are many factors outside the classroom which have much more leverage on whether or not the student will be motivated to learn. The status of the child's homelife, for example, has much more impact on learning than anything a teacher or a computer can do.

Third: intelligence is the most invariant factor in accounting for individual variance in achievement. No matter how poor the teaching method, the bright child will learn—if not in class, then on his/her own. Very few students who are bright and motivated can be hindered by deficiencies in the educational system; for students who are not bright and not motivated very little can be done in the educational system to help them.

These three factors—students and information in the same place at the same time, motivation and intelligence—account for all but 2% to 5% of the variance in student achievement. Even if computers, and personal

computers in particular, could account for all of this last portion, the impact would be minimal.

There are special educational settings in which computers have high leverage in terms of time and money, one of which involves the use of computer simulation. Training a 747 pilot or an intern in threat-to-life situations could be expensive for two reasons: one, the availability of 747's or of heart attack victims is cost-prohibitive; and two, the cost of training time for professionals such as these is expensive. The lower the mean time to complete the course, the more cost-effective the training. Thus, in this case, the use of computers has tremendous advantage.

In the general educational system, however, there is little or no economic advantage to computers. Lowering the mean time to complete a course, for instance, is not economically viable since that would release students either into the workforce (higher unemployment) or into their homes (higher welfare costs, higher juvenile crime rates when both parents are working). The babysitting function of the educational system is essential to the operation of today's society.

In conclusion, the only two technological breakthroughs that have had profound impact on the educational system are books and the blackboard. Other touted technologies, of which the computer is but one example, have had little or no impact. Until the bit cost per page of paper is more than the bit cost of storage on a floppy disk or videodisc, books will remain the most viable teaching tool.

* * * * *

The following are four counter arguments to the above scenario. Please add two more and rate them all on a relative scale — 10 points for the weakest counter argument, more for the others. The ratings should be relative to the strength of the counter arguments.

_____1. Because computers will pervade the US economy, the ability to use a computer will be a necessary component of societal functionality. The logical place for the public to learn about computers is in the schools. Thus, computers, and very likely personal computers, will find their way in large numbers into the educational system. A secondary, ensuant result of computer ubiquity in the schools will be the use of computers for computer-assisted instruction (CAI) on a broad scale.

_____2. Industrial use of computers or personal computers will become standard, which does not imply a necessity for the "retail" area to be knowledgeable about computers. Industry will take over the training of employees in the use of computers by using computers to teach. Thus, personnel will be trained in the most cost-effective manner, that is, in the least possible time, a criterion against which CAI measures up well.

_____3. It may be argued that computers can teach more effectively than 90% of the teachers in the present educational enterprise; therefore, computers can be considered a more effective primary mode of instruction.

Since the cost of computers is going down and the cost of faculty is going up, there will come a time, say in 1985, when the costs will intersect. After that point, computers will be used with increasing frequency to teach.

_____4. The information explosion will continue to accelerate; thus the rate at which school and university curricula have to be revised will also accelerate. The distribution of information, presently handled by book publishers, is slow and cumbersome. However, a computer network that could rapidly distribute tremendous amounts of information to many schools could become an integral part of the functioning of the educational system, thus having a substantial impact on it.

_____5.

_____6.

RATING (10 POINTS FOR WEAKEST ARGUMENT, MORE FOR OTHERS):

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

DETAILED EVENTS QUESTIONNAIRES

Events Associated with Various Education Scenarios

Although many of these events were listed in Round 1, this round contains several new events for your consideration.

For each event, the median estimate of the panel for earliest, most likely, and latest time of occurrence are shown. As in the general event questionnaires, we have listed some precursor conditions that could enhance or inhibit the occurrence of the event (development) together with some impacts from event or development occurrences.

Finally, we have provided scales for indicating the direction and magnitude of the impact of the event, if it occurred, on four trends characterized by the change in sales of microcomputers to:

1. Consumers,
2. Small businesses,
3. Large organizations, and
4. Educational institutions.

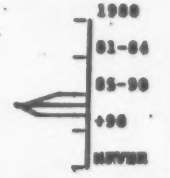
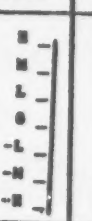
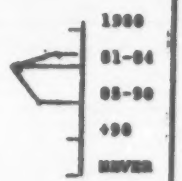
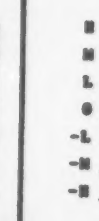
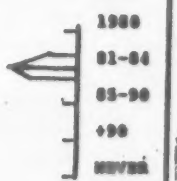
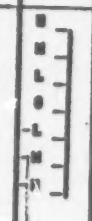
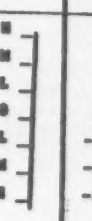
We would like you to:

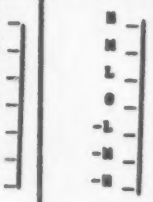
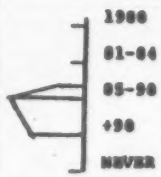
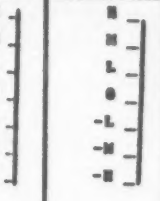
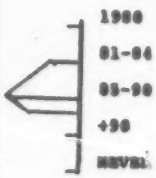
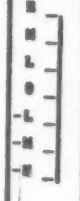
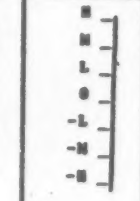
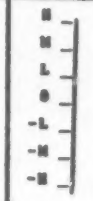
1. Indicate any disagreement on times of occurrences.
2. Add or delete precursor conditions. Change + to -or -to +, if you think we have the direction of enhancement or inhibition wrong.
3. Assess the effects on sales to consumers, small businesses, large organizations, and the educational establishment on the +L to -L scale provided.
4. Add or delete impacts resulting from the event or development.

The following illustration of how a response should look will help you in filling out the questions.

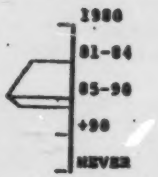
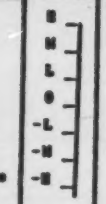
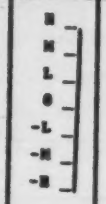
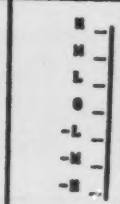
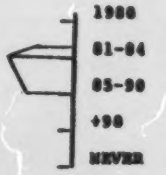
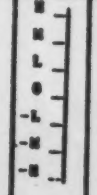
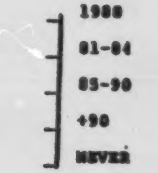
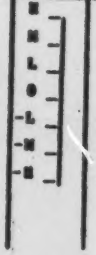
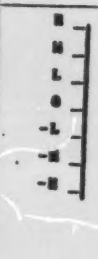
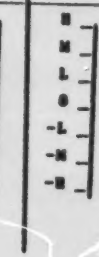
THE PERSONAL COMPUTER AND EDUCATION

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO: HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT	EXPE
1. Experimental program validates utility of PCs in helping slow learners increase their achievement levels.	1980 81-84 85-90 +90 NEVER	+1 Federal report or commission creates alarm over increasing percentage of functionally illiterate. +2 Federal funding of longitudinal study on effects of PCs in education. -1 Reduction in Federal funding for research and evaluation in computer education. -2 Target group too underrepresented to be politically significant.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Schools increase purchases of PCs for special instruction. 2. Increase in commercial production of PC courseware. 3. Supply of entry-level white collar workforce meets demand as slow learners are able to master more knowledge & thus have higher job expectations.	
2. Experimental program validates utility of PCs in helping gifted people increase their achievement levels.	1980 81-84 85-90 +90 NEVER	+1 Federal funding of longitudinal study on effects of PCs in education. -1 Reduction in Federal funding for research and evaluation in computer education. -2 Target group too underrepresented to be politically significant.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Schools increase purchases of PCs for specialized instruction. 2. Increase in commercial production of PC courseware. 3. Functionality gap between gifted & slow learners increases.	
3. Development of extensive PC courseware for slow &/or gifted children using Federal funding.	1980 81-84 85-90 +90 NEVER	+1 Gov't initiates new major thrust in R&D in educational computer technology. +2 Invention of different successful approaches to CAI. +3 Establishment of 5-10 PC curriculum development centers at major universities. -1 Lack of or sporadic Federal funding for PCs in education. -3 Target group too underrepresented to be politically significant.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Percentage of functionally illiterate declines. 2. Increase in commercial production of PC courseware. 3. National grading standards adopted for K-12.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	FACTORS CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO: HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT EXPERTIS
4. Dept of Defense routinely uses PCs for personnel training in basic skills and specialized tasks.		+1 Computers lower mean time to complete course of instruction;thus,are cost effective for military use. -1 Peripheral equipment costs stop decreasing.					1. ROD courseware developments spin off to civilian sector. 2. Educational efficiency improvements reduce training costs thereby freeing budget for increased personnel compensation.
5. Installation of at least 10,000 PCs in schools using Federal matching funds.		+1 Extensive, inexpensive PC software available for administrative applications. +2 Large-scale study in learning motivation at major university supports use of PCs in education. +3 The computer literacy movement develops. -1 No Federal funding of school purchases of PCs. -2 Computer literacy movement does not grow strong.					1. Establishment of PC networks & clubs between school districts to exchange courseware, ideas and developments. 2. PCs in education reach viability; extensive courseware developed commercially. 3. Increased locally-produced CAI. 4. Computer literacy rate doubles.
6. Training in use of PCs available for teachers in at least 10 schools of education.		+1 Demand for minimum competency in a computer language by those hiring high school & college graduates. +2 Knowledge of PC courseware authoring becomes prerequisite for teacher to be hired or upgraded. +3 50% of homes have operating PCs. -1 Majority of teachers resist use of of PCs.					1. Increased competition in PC courseware field between commercially produced CAI & locally produced materials. 2. Less teacher resistance or apathy toward PCs.

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO HOME	IMPACT ON SALES TO SMALL BUSINESS	IMPACT ON SALES TO LARGE ORGANIZATION	IMPACT ON SALES TO EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT	EXPL
7. One of 10 largest states requires demonstrated ability to operate a terminal as condition for high school graduation.		+1 Demand for minimum competency in a computer language by those hiring high school & college graduates.					1. Rate of diffusion of computer technology throughout society increased.	
8. High quality PC courseware becomes available for 25 different high school courses, including those required for graduation.		+1 Textbook publishers provide extensive school-district-adaptable PC courseware. +2 Improvement of copyright or other protection of courseware. +3 PC courseware accredited by 3 populous states. -1 PC industry ignores educational market.					1. Self-paced, home use of PC courseware approved by school districts. 2. The 3-and 4-year high school becomes obsolete as time required to finish graduation requirements decreases. 3a. Replacement for school as "baby-sitting" institution model. 3. As greater number of students study at home, school bldgs are modified for multi-use.	
9. Computer literacy questions appear on SATs.		+1 AAU & other universities require computer literacy for entering freshmen. -1 No SAT questions on use of calculator.					1. Courses in computers (programming & maintenance) are required in high school.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD INDICATE OR IMPACT	IMPACT ON SALES TO: HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT	EXPER
10. PCs for use in physical education are marketed successfully.	1988 81-84 85-90 +90 NEVER	+1 Demonstration of utility of PCs in accelerating training effects. +2 Adoption of "sports medicine" technologies by amateur & high school athletic departments. +3 Development of "all-weather" PCs. -1 Catastrophic event resulting from use of PC(e.g.victim of fatal exercise program).	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Extension of use of PCs from sports medicine to other health-related fields. 2. 20% increase in US Olympic gold medals. 3. School athletic departments invest more heavily in PCs.	
11. PCs are used in conjunction with videotaped lectures for continuing education credit courses for home use by a major college or univer-	1988 81-84 85-90 +90 NEVER	+1 Three major cities have local distribution of digital telecommunications. +2 Establishment of US Open of "open university." +3 Program to develop courseware for PC-based college courses established. -1 Rise in telecommunications costs: increasing phone rates, strict enforcement of data transmission tariffs, metering of local calls,etc.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Average level of education in US increases. 2. De facto discrimination against those who can't afford PC hardware.	
12. PCs are used in conjunction with videotaped lectures for continuing education credit courses for home use by a large vocational training institute.	1988 81-84 85-90 +90 NEVER	+1 Establishment of public PC telecommunications network. +2 Establishment of US Open of "open university." +3 Development by EDD of extensive CAI courseware.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. "Mal-practice" in auto repair business decreases by 50%.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT EFFORT
13. 10,000 PCs used in production operations are provided with educational courseware for on-the-job training.		+1 PC courseware becomes available that makes instruction via PCs cost-effective for industry. +2 10% of Fortune 500 companies adopt PCs for white collar job training. +3 Major publisher or other firm enters industrial training market using PCs as its market differentiation. +4 AT&T, IBM or some other industrial firm markets basic CAI module software development for industrial(in-plant) training.					1. Greater productivity results from lowering mean time to train employees.
14. Federal funds made available for PCs in schools for use by handicapped, disadvantaged.		+1 Federal funding of longitudinal study on the effects of PCs in education. +2 Breakthroughs in applications of PCs for handicapped. -1 Target group too underrepresented to be politically significant.					1. Increased integration of handicapped & disadvantaged in educational system.
15. DOD supports development of CAI modules for PCs.		+1 New DOD study indicates that PCs are cost-effective for training recruits.					1. Courseware is used for civilian applications. 2. Development of CAI module interface that facilitates authoring CAI materials.

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECISE CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES TO: HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT EXPER
16. AT&T, IBM or some other industrial firm markets basic CAI module software development for industrial (in-plant) training.	1980 81-84 85-90 +90 NEVER	+1 Successful marketing of "algorithm" for authoring CAI modules. +2 Industry-wide CAI modules are developed; e.g. in telecommunications & insurance industries. +3 Courseware modules shown to be widely transferable within an industry.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Competition among courseware suppliers is stifled. 2. Modular approach adopted by formal educational system.
17. 50% of newly published vocational training material is available in a form that can be used in PCs.	1980 81-84 85-90 +90 NEVER	+1 Establishment of public PC telecommunications network. +2 Development by DOD of extensive CAI courseware.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. "Mal-practice" in auto repair business decreases by 50%.
18. 30% of administrative data processing conducted in education (K-college) is accounted for by PCs.	1980 81-84 85-90 +90 NEVER	+1 Combination of Federal & state reporting requirements & reduced school budgets dictate conversion to PCs for administrative uses.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased use of PCs for administrative data processing leads to similar increases in computer literacy, CAI applications. 2. Specialized PC software becomes available for education administration (including appropriate interfaces with state & Federal reporting systems).

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD EMBRACE OR INHIBIT	IMPACT ON SALES TO: HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT
1. Experimental program validates utility of PCs in helping average learners to increase their achievement levels.	1980 81-84 85-90 +90 NEVER	+1 Federal funding of longitudinal study on effects of PCs in education. -1 Reduction in Federal funding for research & evaluation in computer education. -2 PC industry ignores educational market.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase in commercial production of PC courseware. 2. External pressure from groups such as the PTA forces schools to acquire PCs.
2. Majority of elementary & secondary schools in a large state have 1/2-day sessions with balance of education taking place at home on PCs.	1980 81-84 85-90 +90 NEVER	+1 Budget limitations force reduction in school personnel. +2 Energy costs prohibit full use of school facilities. -1 Significant parent resistance develops.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Number of women in full-time labor force decreases because they have to remain at home some portion of day with their children. 2. Job sharing (in which two or more persons combine efforts to perform single job) increases proportionately.
3. High school students in one of 10 largest states have option of taking courses on PCs either at school or home.	1980 81-84 85-90 +90 NEVER	+1 High quality PC courseware becomes available for most high school courses. +2 Congress passes national tuition tax credit. +3 The state legislature of a large state passes the "voucher system" whereby state-applied tuition aid may be applied to institution of parental choice.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Number of women in full-time labor force decreases because they have to remain at home some portion of day with their children. 2. Job sharing (in which two or more persons combine efforts to perform single job) increases proportionately. 3. Drug addiction & property crime increase among unsupervised children.

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECEDENCE CONDITIONS THAT COULD INFLUENCE OR BENEFIT	IMPACT ON SALES TO: HOME	IMPACT ON SALES TO: SMALL BUSINESS	IMPACT ON SALES TO: LARGE ORGANIZATION	IMPACT ON SALES TO: EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT	EXPI
22. Majority of plant managers realise educational value of PCs in terms of cost-effectiveness of PCs in employee training.	1988 81-84 85-90 +90 NEVER	+1 PC courseware becomes available that makes instruction via PCs cost-effective for industry. +2 Major publisher or other firm enters industrial training market using PCs as its market differentiation. +3 10% of Fortune 500 companies adopt PCs for white collar job training.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Greater productivity results from lowering mean time to train employees.	
23. Significant shifts in educational data processing occur towards utilising PCs for administrative applications.	1988 81-84 85-90 +90 NEVER	+1 Combination of Federal & state reporting requirements & reduced school budgets dictate conversion to PCs for administrative uses.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased use of PCs for administrative data processing leads to similar increases in computer literacy, CAI applications. 2. Specialised PC software becomes available for education administration(including appropriate interfaces with state & Federal reporting systems).	
24. General public ownership of PCs exceeds 75%, therefore educational system is forced to make use of PCs.	1988 81-84 85-90 +90 NEVER	-1 PC enthusiasm is confined to upper-middle class.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Computer literacy level matches traditional literacy level in US. 2. US workforce retains superiority over other countries in production.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD REINFORCE OR INHIBIT	IMPACT ON SALES TO HOME	SMALL BUSINESS	LARGE ORGANIZATION	EDUCATION	IMPACTS RESULTING FROM DEVELOPMENT
25. Active promotion by Federal agencies of education at home via PCs and PC courseware.	1980 81-84 85-90 +90 NEVER	+1 Establishment of US form of "open university." +2 Energy costs dictate increased homing. +3 Congress passes nat'l tuition tax credit. +4 State legislature of large state passes "voucher system" whereby state-supplied tuition aid may be applied to an institution of parental choice.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Self-paced, home use of PC courseware approved by school districts. 2. The 3-or 4-year high school becomes obsolete as time required to finish graduation requirements decreases. 3a. Replacement for school as a "baby-sitting" institution is needed. 3. A greater number of students study at home, school bldgs are modified for multi-use. 4. Minority groups resist introduction of PCs as "cover" for segregation.

THE PERSONAL COMPUTER AND THE WORKFORCE

Discussion of Round 1 Results

The first round Delphi presented a ten part scenario for potential impacts of personal computers on the workforce. You were asked whether you generally agreed, disagreed, or were neutral about each part. The next page shows the detailed results for these ten scenariolets. The results can be summarized by stating that the panel agreed that:

- PCs would reduce the shortage of clerical workers. (Part 1)
- PCs would bring automation and on-line data processing to small business (Part 4).
- PCs would be used for on-the-job retraining.(Part 8)

The panel was divided on four possibilities (at least half agreed or were neutral):

- PCs become a way of employer's coping with the energy crisis by permitting workers to work at home or at remote work sites. (Part 2)
- Government aid programs for the handicapped include purchase of PCs. (Part 3)
- Because PCs are available, government agencies increase record-keeping requirements for small businesses. (Part 6)
- The role of middle managers changes and the number of middle managers decreases because of the presence of PCs. (Part 9)

The panel rejected three possibilities (more than half disagreed):

- As PCs are introduced, older workers are less able to adapt to the new environment and are displaced. (Part 5)
- PCs are widely adopted in do-it-yourself tasks, thereby reducing demand for crafts workers. (Part 7)
- The proportion of white collar to blue collar jobs in corporations decreases. (Part 10)

The panel felt that the most likely time that the scenario as a whole would be implemented was after 1990. The panel was divided on the most likely time for PCs to be installed in 10,000 small manufacturing plants in the U.S., with half feeling it would be before 1985 and half feeling that it would be between 1985 and 1990. The most likely time for PCs to be installed in 100,000 US retail establishments was judged to be 1985-90. The detailed responses are shown on the next page in the same format as the general event data.

In general, there was disagreement with the various policy scenarios laid out. As shown in the detailed analysis that follows, only two policy scenarios (the Department of Education's Bureau of Vocational Education encourages PC curricula in community colleges, and changes in the Federal transfer payment

program due to worker displacement) received as many as four votes of agreement out of a panel of twelve.

The overall implication was that the marketplace rather than the Federal government was likely to shape the course of events.

SUMMARY OF RESULTS ON WORKFORCE SCENARIOS

I. IMPACT SCENARIO.

	AGREE	DISAGREE	NEUTRAL
1. PCs reduce shortage of clerical workers.	10	1	1
2. PCs used to cope with energy crisis.	4	5	3
3. PCs purchased for handicapped.	5	4	3
4. PCs used for small business white collar automation.	11	1	0
5. Older workers displaced by PCs.	3	7	2
6. Gov't records requirements offset productivity gains from PCs.	3	6	3
7. PCs for do-it-yourself replaces craftsman	3	7	2
8. PCs used for on-the-job retraining.	9	1	2
9. PCs displace middle managers.	3	5	4
10. Proportion of white collar workers reduced.	1	8	3

	TIME OF OCCURRENCE			
	1980	81-84	85-90	>90
EVENT 1. General Outline of Impact Scenario Occurs.				
E	-	5/12	7/12	-
M	-	2/12	3/12	7/12
L	-	1/12	2/12	7/12
EVENT 2. Personal computers are installed in 10,000 small manufacturing plants in U.S.				
E	2/12	8/12	1/12	1/12
M	-	5/12	6/12	1/12
L	-	2/12	6/12	4/12
EVENT 3. Personal computers installed in 100,000 retail businesses in U.S.				
E	1/12	8/12	1/12	1/12
M	-	4/12	6/12	2/12
L	-	-	6/12	6/12

POLICY SCENARIOS

	AGREE	DISAGREE	NEUTRAL
1. Gov't declares it to be its obligation to provide work.	3	6	3
2. Workers over 40 must be retrained to use computers.	1	8	3
3. DOE Bureau of Vocational Education encourages PC curricula in community colleges.	6	4	2
4. Bureau of Labor Statistics issues computer-related workforce data.	3	6	3
5. Retraining of engineers to smooth technical workforce supply.	1	8	3
6. Job is viewed as privilege, not right.	1	10	1
7. PC transfer payments change.	4	6	2
8. Federal workforce changes from PC use.	1	8	4

ESTIMATES OF NET EFFECTS.

	INCREASE	DECREASE	UNCHANGED	NO OPINION
Total number of businesses.	5	2	2	1
Total number of clerical jobs.	4	6	3	-
Total number of middle management jobs.	4	1	7	-
Job mobility.	7	0	4	1
Clerical job complexity.	8	1	2	1
Management job complexity.	7	1	3	1
Job routinization.	4	6	2	-
Clerical workers supply relative to demand.	3	6	2	1
Labor force change due to do-it-yourself.	1	2	7	2
Skilled trades for service.	1	3	7	1
Flow from white to blue collar.	3	2	6	1

More than half the panelists agreed that:

Job mobility, clerical job complexity and management job complexity would increase.

The total number of middle management jobs would be unchanged and there would be no impact on the labor force from use of PCs for do-it-yourself and skilled trade tasks.

The panelists did not have a clear majority view, but did have general indications on the other questions asked. The split between "increase and decrease" for some effects, such as change in routinization, could be ascribed to a diversity of impacts; some jobs becoming more routine, others less so. Note that this split may be correlated with work supply changes.

COMPOSITE SCENARIO

The following is a list of events that affect the workforce. The events have been sequenced in order of occurrence as specified by the median estimate of the most likely time of occurrence from Round 1. This list can be viewed as a scenario.

Please review this list. Consider the TIMING of the events in terms of:

1. Their likely time of occurrence.
2. Their sequence relative to one another.

FEEL FREE TO CHANGE ANY DATE INDICATED.

In making your assessment, keep in mind that these "likely" dates represent a 50 percent chance of the events occurring by that time, not certainty.

EXAMPLE

If you want to change a date, follow the example shown below in which a respondent might change an event from 1985 to 1987.

1985 1987 IRS rules permit fast depreciation of PCs.

* * * * * *

YEAR	EVENT SCENARIO
1980	A portion of the workforce proves to be untrainable for the use of computers.
1982	PCs with specialized software marketed to aid sales in small retail stores.
1983	A Kelly Girl service using PCs and phonelines is offered commercially.
1983	A survey shows that more than half of all home PC users consider the most important use to be games.
1985	10,000 workers in the U.S. use PCs at work locations in or close to their homes to perform clerical functions for remotely located employers.
1985	IRS rules permit fast depreciation of PCs.
1987	Government subsidy of educational programs on PC use by businesses.
1985	A major drop in information network services costs and service bureau charges make service bureaus competitive with PCs for small businesses (note: 3 say 1985; 4 say never).
1985	A survey shows that more than half of all home PC users consider the most important home use to be do-it-yourself instruction.
1988	A government program providing PCs to handicapped people as employment aids is funded.
1988	A survey shows that more than half of all home PC users consider the most important use to be education.

1988 Another survey shows that more than half of all home PC users consider the most important use to be work at home.

1990 Retraining programs are established for older workers displaced by PCs.

1995 IRS requires computer-kept records for all businesses that do more than $[illegible],000 per year gross.

1995 Two percent of the labor force (4% of white collar) is chronically unemployed as a direct result of job substitution by small computers.

1995 A survey shows that more than half of all home PC users consider the most important use to be text processing.

2000 IRS provides computer programs that can be used on PCs for tax records.

DETAILED EVENTS QUESTIONNAIRES

The following pages show events associated with various workforce scenarios. These events have been placed into four groups:

1. Worker displacement and training (resulting in changes in workforce composition).
2. Substitution of communications for transportation (resulting in changes in workforce location and access to work for workers).
3. IRS requirements (resulting in changes of accounting for PCs and in record-keeping requirements for businesses).
4. Competition (to PCs from network information services and service bureaus).

The numbers refer to the order in the original questionnaire.

For each event, the median estimate of the panel for earliest, most likely, and latest time of occurrence are shown. In a few cases, the panel was split with half the panelists feeling that the event would never occur or that the latest time was never. These are indicated by "or NEVER."

As in the general event questionnaires, we have listed some precursor conditions that could enhance or inhibit the occurrence of the event, together with some impacts from event occurrences.

Finally, we have provided scales for indicating the direction and magnitude of the impact of the event, if it occurred on three trends:

1. The size of the workforce employed.
2. The number of workers displaced.
3. The supply of clerical workers relative to the demand for clericals.

We would like you to:

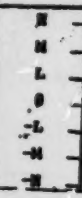
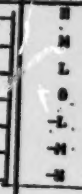
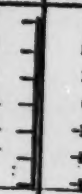
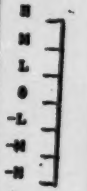
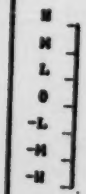
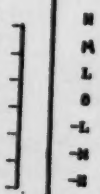
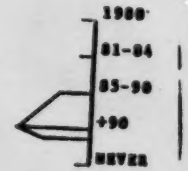
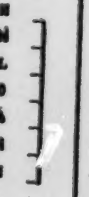
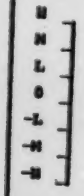
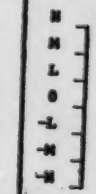
1. Indicate any disagreement on times of occurrences.
2. Add or delete precursor conditions. Change + to - or - to + if you think we have the direction of enhancement or inhibition wrong.
3. Assess the effects on workforce, displaced workers, and clerical labor supply on the +L to -L scale provided.
4. Add or delete impacts resulting from the event.

The following illustration of how a response should look will help you in filling out the questions.

THE PERSONAL COMPUTER AND THE WORKFORCE

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD EMBRACE OR EMERGE	EFFECT ON WORKFORCE EMPLOYED	# OF DISPLACED WORKERS	CLERICAL LABOR SUPPLY RELATIVE TO DEMAND	IMPACTS RESULTING FROM EVENT	EXPERTISE
I. WORKER DISPLACEMENT AND TRAINING	1988		H	H	H		
13. 2% of labor force (4% white collar) chronically unemployed because of PC substitution.	84-88	-1 White collar productivity gains offset by increased paperwork requirements.	M	M	M	1. No subsidies to business to train in PC use. 2. No retraining for older workers. 3. No subsidy for PCs for handicapped.	
	88-90		L	L	L		
	+90		0	0	0		
	NEVER		-L	-L	-L		
			-M	-M	-M		
			-H	-H	-H		
12. A portion of workforce proves to be untrainable in computers.	1988	+1 A Luddite-type anticomputerism makes people hostile to computers.	H	H	H	1. Union opposition to PCs in business. 2. Chronic unemployment. 3. Wally girl services offered to cover shortages of workers.	
	84-88	-1 New training methods developed. -2 English-like instructions developed.	M	M	M		
	88-90		L	L	L		
	+90		0	0	0		
	NEVER		-L	-L	-L		
			-M	-M	-M		
			-H	-H	-H		
3. Retraining programs established for older workers displaced by PCs.	1988	+1 Social security program difficulties cause gov't to try to keep people working longer. +2 Shortage of clerical workers with requisite PC skills. -1 Tests indicate that older workers are less able to absorb computer concepts.	H	H	H	1. Shortage of clericals relieved. 2. Increased workers at or near home.	
	84-88		M	M	M		
	88-90		L	L	L		
	+90		0	0	0		
	NEVER		-L	-L	-L		
			-M	-M	-M		
			-H	-H	-H		

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	EFFECT ON WORKFORCE EMPLOYED	# OF DISPLACED WORKERS	CLERICAL LABOR SUPPLY RELATIVE TO DEMAND	IMPACTS RESULTING FROM EVENT	EXPERTISE
5. A gov't program is funded to provide PCs to institutionalized people as employment aids.	1988 82-84 85-90 +90 NEVER	+1 Shortage of clerical workers with requisite skills. +2 Low-cost communications. -1 High unemployment among population as a whole.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Shortage of clericals reduced. 2. Increased workers at or near home.	
7. Gov't subsidy of educational programs on PC use by businesses.	1988 84-84 85-90 +90 NEVER	+1 IRS establishes requirement for computer-based records. +2 Tests show real white collar productivity gains. +3 PC industry lobbying of Congress.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. IRS establishes record-keeping requirements. 2. Increased workers at or near home. 3. Shortage of clericals reduced.	
II. SUBSTITUTION OF COMMUNICATIONS FOR TRANSPORTATION							
1. 10,000 workers in US use PCs at work locations close to home for remotely located employers.	1988 84-84 85-90 +90 NEVER	+1 Rapid rise in transportation/energy costs. +2 Reduced communications costs. +3 Increased shortage of clerical workers willing(or able)to travel downtown. -1 Shortage of phone lines.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Rapid introduction of PCs for remote use by employers.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	EFFECT ON WORK FORCE EMPLOYED	# OF DISPLACED WORKERS	CLERICAL LABOR SUPPLY RELATIVE TO DEMAND	IMPACTS RESULTING FROM INHIBIT	EXPERTISE
4. "Wally Girl" service using PCs and phone lines offered commercially.		+1 Rapid rise in transporation/ energy costs. +2 Reduced communications costs. +3 Increased shortage of clerical workers willing(or able)to travel -1 Increasing concern for privacy. -3 Phone line shortage.				1. Faster introduction of PCs into business.	
III. IRS REQUIREMENTS 6. IRS permits fast PC depreciation.		+1 IRS demands computer record keeping. +2 Federal stimulation of productivity for white collar services.				1. Faster introduction of PCs into business.	
8. IRS requires computer-kept records for all businesses with more than $15,000 gross.		+1 A successful demonstration project is run by the IRS. +2 IRS provides or validates computer programs for PC tax records.					

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	EFFECT ON WORKFORCE EMPLOYMENT	# OF DISPLACED WORKERS	CLERICAL LABOR SUPPLY RELATIVE TO DEMAND	IMPACTS DEVELOPING FROM TREND	EXPERTISE
IRS provides computer programs that can be used on PCs for tax records.	1988 81-84 85-90 +90 NEVER	+1 IRS requires computer-kept records. -1 Software-house lobbying against "government giveaway."	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H		
COMPETITION A major drop in information network services costs & service bureau charges make service bureaus competitive with PCs for small businesses.	1988 81-84 85-90 +90 NEVER	+1 Major reduction in phone costs. +2 Rapid growth in network information. -1 Regulatory barriers limit extent of service.	H M L 0 -L -M -H	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Slowing of PC use.	

The first round Delphi elicited too few answers from individuals who rated themselves as having moderate to high expertise to include a summary of those questions in this round. Consequently, we have taken the option of readdressing the questions to the entire Delphi panel. The following pages show events associated with various factors relevant to the impact of personal computer technology on international trade. These events have been placed into three groups:

1. The general viability of the US personal computer industry.
2. The effects of international trade on the domestic market for personal computers.
3. The effects of personal computer technology on the world market.

For each development listed, we would like you to indicate your opinion as to the earliest, most likely and latest time of occurrence of the development indicated. As in the general event questionnaires, we have listed some precursor conditions that could enhance or inhibit the occurrence of the development, together with some possible impacts resulting from the occurrence of the development.

Finally, we have provided scales for indicating the direction and magnitude of the impact of the development, if it occurred, on domestic and foreign sales of US manufactured PCs.

We would like you to:

1. Add or delete precursor conditions. Change + to -or -to +, if you think we have the direction of enhancement or inhibition wrong.
2. Assess the effects on sales of US manufactured personal computers in the domestic and world markets on the +L and -L scale provided.
3. Add or delete impacts resulting from the hypothetical development.

The following illustration of how a response should look will help you in filling out the questions.

SUMMARY DATA ON EVENTS

KEY:

The following are the results of the first round Delphi. The raw data are presented for the panel as a whole. These data, for example, may be shown as:

E	74	21	3	3	-
M	39	51	7	-	3
L	16	53	26	3	3
	80	81-84	85-90	>90	NEVER

Here: E = earliest; M = most likely; L = latest
The numbers indicate the percentage in each category;
- indicates none.
80, 81-84, 85-90, >90 and NEVER indicate the time period.

Two additional sets of data are shown where applicable.

E	[////]	21	3	3	-
M	[////]	51	7	-	3
L	16	[////]	26	3	3
	80	81-84	85-90	>90	NEVER

Here: the /////// indicates the median for those who rated themselves high expertise; the [ ] indicates consensus was considered achieved.

Note that in some cases, particularly those where market or technical questions are involved, we may accept the experts rather than the group as a whole for consensus.

Finally, to aid you in interpreting the results, we show you the number of respondents, N, and the number who rated themselves high expertise, H. Thus, for example,

N = 41 H = 13

implies 41 answered this question, of whom 13 rated themselves expert.

EVENT 1. A national retailer enters the PC market.

	80	81-84	85-90	>90	NEVER
E	[illegible]	21	3	3	-
M	[illegible]	51	7	-	3
L	16	[illegible]	26	3	3

N = 41 H = 13

EVENT 2. One of the manufacturers of large mainframes enters the PC market.

E	26	[illegible]	13	3	-
M	5	[illegible]	20	10	5
L	-	21	[illegible]	18	16

N = 41 H = 14

EVENT 3. Two large calculator companies enter the PC market.

E	[illegible]	20	-	-	-
M	[illegible]	54	5	-	-
L	13	[illegible]	29	3	3

N = 41 H = 19

EVENT 4. A major US company not now in the PC market enters the market.

E	[illegible]	[illegible]	10	3	-
M	5	[illegible]	37	10	2
L	3	18	[illegible]	23	15

N = 40 H = 6

EVENT 5. A 32-bit address register is introduced by one of four top PC manufacturers.

E	38	[illegible]	-	-	-
M	3	[illegible]	36	-	-
L	3	27	[illegible]	18	3

N = 40 H = 11

EVENT 6. A major foreign-owned corporation enters the PC mainframe market in US.

E	[illegible]	39		-	-
M	[illegible]	73	10	-	-
L	-	[illegible]	32	13	-

N = 41 H = 6

I. PARTICIPANTS IN THE MARKETPLACE

Events 1, 2, 3, 4 and 6 dealt with the possible entry of various participants into the marketplace. In general there was good agreement that these entries would occur early in the cycle, either by the end of 1980 or in the 81-84 period. There was less agreement on whether or when a CB-like craze for home computer entertainment would occur. Of 38 panelists who estimated latest occurrence, 12 indicated it might never happen.

Since the first questionnaire was issued, the following have occurred:

1. Sears is selling ATARI computers. Because of Sears' historical conservatism in introduction of new lines, this probably represents a long-term commitment, although the exact form of their marketing efforts may change.
2. Xerox has been added to the list of non-mainframe manufacturers who may enter the market. Such entry could, incidentally, be either with their own brand name or through acquisition of an existing manufacturer.
3. Hewlett-Packard has introduced their HP-85 Professional Personal Computer which, with Texas Instruments' TI 99/4, fulfills the condition that two major calculator manufacturers enter the market. The HP-41C programmable hand calculator-cum-printer is almost a personal computer by our definition, but is too restricted in application.

II. NETWORK INFORMATION SERVICES

The agreement on network information services questions was much less than on market questions. In particular, there were sizable groups who believed that neither polling nor revision of the 1934 Communications Act would ever occur.

In considering the network services, recognize that there are at least two firms currently offering commercial services directed to the personal computer user — MICRONET (Compuserve, Inc.) and The Source (Telecomputing Corporation of America). For purposes of EVENTS 8 and 9, do not consider these services to be events that satisfy the criterion since it is not clear at this time whether they are viable over the long-term. There are other indications of network service activity, including experiments by AT&T and trials, using a GTE-owned PDP-11 computer in Tampa, of the Viewdata system.

III. TECHNOLOGY

The purpose of the technology questions was to obtain a baseline check against the analysis which USC performed during the first phase of the project. We selected three developments: one in computer architecture, one in peripherals and one in concept of design.

To help you in the second round, the following are more detailed descriptions of these developments. Development of a 32-bit address register for personal computers implies that low-cost

main memory is available to the computer. The further implication is that personal computer applications requiring extensive memory access and probably using 16, 24, or 32-bit microprocessors, are possible for low-cost systems. Foremost among these application areas would be high quality, dynamic, color graphics, sophisticated direct voice input, and complex computer-assisted instruction programs. The question concerning commercialization of a low-cost flat screen deals with the issue of providing very low-cost consumer computers — at the $250 level or less. Development of a Dynabook-size personal computer, which essentially requires the existence of the previous two developments, connotes the arrival of the truly personal, easily portable computer.

IV. CRIME

Computer crime is a subject that fascinates many and which PCs may well exacerbate. We included four events in our general set of events; we also had a separate, detailed inquiry.

The first event postulated a law that would require registry of PC ownership. The concept was that there is an analogy between a computer-aided, white-collar crime and a weapon-aided burglary; both provide the criminal with leverage that s/he does not have without mechanical aid. Computer registration would thus, in a sense, be analogous to gun registration or to CB registration. The former has had considerable opposition, whereas the latter is done routinely. Such registration would aid both in detecting thefts of PCs and reducing the probability of such occurrences. If registration were to occur at all, it probably would not occur until 1985 or later, according to our panelists.

Two questions dealt with measures to protect software from piracy. We recognize the difficulty in defining what is "pirate-resistant." A simple criterion might be measures which, if implemented, would make the cost of pirated software equal to or close to the cost of honestly produced software. Such parity could be achieved by making software cheap (i.e., the marginal cost of the software would be small relative to the cost of the recording medium and packaging) thereby reducing the incentive to pirate, or by making piracy expensive via criminal statutes or tort law. Consequently, we have rephrased the question in this round.

One approach to protecting data and software is to provide encryption. Recent developments in encryption for large mainframes may well be transferrable to PCs at reasonable cost. A patent has been issued to Robert M. Best of Seattle, Washington, for a PC-oriented software encryption system; a cryptomicroprocessor. The question should be examined thus in the light of whether such transfer is feasible at reasonable cost and, if it is, whether it is likely to occur.

V. OTHER SOCIETAL ISSUES

These questions focus on two societal issues other than crime — privacy and equity.

The first event, enactment of legislation which makes PCs

subject to the Privacy Act of 1974 is based on the assumption that the widespread use of PCs will result in concern about the possibility of intruding into personal lives with these machines. The range of problems runs from the local boutique's maintaining credit and other information about customers to the transmission of malicious gossip over PC nets. The issues are complicated by the question of what constitutes private data; for example, must all people on a Christmas card list be notified they are on the list? The last might seem patently absurd, but stranger things have happened in the past. The Privacy Law of 1974, in brief, requires that Federal agencies make public the existence of data bases containing information about individuals, allow the affected individuals to examine the contents of files concerning them (with certain restrictions), and require correction of any errors found.

We do not show concensus on this question; however, there is clear indication that the panel felt that action was considerably down the road and that there is a strong possiblity that PCs may never come under privacy legislation.

The second event dealt with measures to provide PC access to the poor. It can be argued that if PCs become widespread, they provide information capabilities that would make it even more difficult for people with low incomes and little training to compete in the job market. A class of "information poor" might be created. One way of overcoming such class differentiations would be to provide public access to PCs. Our model is the availability of library facilities that provide access to books, magazines, records and, more recently in many places, to video recorders. The implication is that the public access PCs would also provide the opportunity to learn how to operate (and program) machines.

The opinion of the panel is that public access to PCs would occur only after widespread adoption of such subsidized use.

VI. APPLICATIONS

We sampled four applications areas for PCs:

- educational use; in particular, elementary school use;
- home monitoring
- government-mandated use; and
- energy conservation

In the case of educational software, the concensus was that such software was near at hand, within a year or two - and certainly in five years. There are indications that many firms are in the educational market; McGraw-Hill and other publishers are issuing books on the use of BASIC for specific PCs; EDS and other firms are marketing video tapes and other learning aids. Apple and Bell&Howell are entering the CAI market. Bills setting up personal computer projects in the Department of Education are being introduced. The Dallas School District is selling to other districts some of the courseware it developed for its TRS-80s. These activities indicate great interest in the educational market. The question asks whether this interest will translate into the widespread marketing of courseware for the elementary school level in particular.

The use of PCs for home monitoring is well established. At present, it is usually a retrofit; in the future it might be reasonable to expect that PC-based monitoring would be built in to a house just as intercom systems and smoke detection systems are currently included in above-average cost homes. In framing our question, we chose a price of $100,000 as the cutoff in terms of 1978 dollars. A number of our respondents, particularly in Southern California, felt that this represented a very cheap house. Although the Southern California market has inflated, the median price of a new house nationally in 1978 was in the $60,000 range and even in Southern California was under $100,000. For purposes of answering this question, you may consider the $100,000 value to represent houses in the top quarter of those being built.

Our question on IRS requirements is based on conversations with the IRS that indicate that the IRS is presently considering such a move for the mid-to late-1980s. We seek the panel's view as to whether the agency will be able to meet such a goal. There may be institutional barriers within the government or lobbies outside the government that would either speed or delay such an action.

The substitution of communication for transportion has been discussed and researched since the 1960s. Do PCs combined with an energy-short environment, particularly rising gasoline costs or decreasing availability of fuel, provide technological and economic leverage to begin implementation of this concept?

THE PERSONAL COMPUTER AND INTERNATIONAL TRADE

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES OF US MANUFACTURED PCS: DOMESTIC	IMPACT ON SALES OF US MANUFACTURED PCS: FOREIGN	IMPACTS RESULTING FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
1. GENERAL VIABILITY OF U.S. INDUSTRY 1. MEF and/or RED establish major (>$200 million over 4 years) microcomputer R&D programs.	1980 81-84 85-90 +90 NEVER	+1 Foreign competitors capture more than 25% of US market. +2 Domestic needs for advanced microelectronics exceed capacity of US suppliers. +2 Increased Federal R&D budget. -1 Decreased Federal R&D spending. -2 Shift in R&D priorities to other fields, e.g. energy.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Enhancement of US balance of payments position. 2. Increase in US technological lead vis-a-vis other countries.	
2. IRS allows investment tax credits for R&D writeoff of computer equipment.	1980 81-84 85-90 +90 NEVER	+1 Intense lobbying by microelectronics/computer industry. -1 Perception by Congress of anti-special interest sentiment.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. General increase in US R&D investment. 2. Enhancement of US balance of payments position.	
3. 1/3 of US PC semiconductor manufacturing output is at least 1/3 owned by foreign interests.	1980 81-84 85-90 +90 NEVER	-1 US policy banning foreign ownship of US companies.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased rate of technology transfer between participant countries. 2. Little short-term(5 yr)change in US balance of payments position. 3. Long-term worsening of US balance of payments position.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES OF US MANUFACTURED ECE: DOMESTIC	IMPACT ON SALES OF US MANUFACTURED ECE: FOREIGN	IMPACTS RESULTING FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
II. DOMESTIC MARKET	1980 81-84 85-90 +90 NEVER		H M L 0 -L -M -H	H M L 0 -L -M -H		
4. Japanese directly enter US market with complete consumer computer systems.		+1 Failure of US firms to meet market demands. +2 Japanese gov't backs two-tiered pricing policy. +3 Japanese eliminate manufacturing tax for PC exports. -1 Imposition of US restrictive import barriers(quotas,tariffs).			1. Worsening of US balance of payments position. 2. Increased pressure by manufacturers for Federal intervention. 3. Increasing takeover of US consumer electronics market by Japanese firms. 4. Increased multinational firms activity.	
5. Japanese directly enter US market with complete business PCs.	1980 81-84 85-90 +90 NEVER	+1 Failure of US firms to meet market demands. +2 Japanese gov't backs two-tiered pricing policy. +3 Japanese eliminate manufacturing tax for PC exports. -1 Imposition of US import barriers.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Worsening of US balance of payments position. 2. Increased pressure by manufacturers for Federal intervention. 3. Increased incursion by Japan into mkt for larger computers. 4. Increased multinational firm activity.	
6. EEC countries (Great Britain, France, W. Germany Netherlands) enter US market in force.	1980 81-84 85-90 +90 NEVER	+1 Failure of US firms to meet market demands. +2 Elimination of VAT on foreign exports to US. +3 EEC gov't subsidy of R&D, export trade. -1 Imposition of US import barriers.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Worsening of US balance of payments position. 2. Increased pressure by mfgrs. for Federal intervention. 3. Increased multinational firm activity.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES OF US MANUFACTURED PCs: DOMESTIC	IMPACT ON SALES OF US MANUFACTURED PCs: FOREIGN	IMPACTS RESULTING FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
7. US Dept. of Commerce and/or Small Business Admin. establish. development support programs (low interest loans, loan guarantees) to US PC hardware, software producers.	1980 81-84 85-90 +90 NEVER	+1 Extension of Trade Adjustment Act to include anticipatory aid (i.e. aid prior to absolute loss of sales due to import competition).	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Slight improvement of US balance of payments position (compared with effect of tax incentives). 2. Increase in multinational firm activity(if prescribed by Trade Adjustment Act).	
8. Foreign producers capture at least 30% of US PC market.	1980 81-84 85-90 +90 NEVER	+1 Failure of US firms to meet market demands. +2 Elimination of VAT on foreign exports to US. +3 Foreign gov't subsidy of R&D, export trade. -1 Imposition of US import barriers.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Worsening of US balance of payments position. 2. Increase of pressure for Federal action.	
9. Foreign firms "dump" PCs in US market, successfully driving small & medium-sized US firms out of business.	1980 81-84 85-90 +90 NEVER	+1 Failure of US firms to meet market demand. +2 Elimination of VAT on foreign exports to US. +3 Foreign gov't subsidy of R&D, export trade, support of two-tier pricing. -1 Imposition of US import barriers.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Worsening of US balance of payments position. 2. Increase in US high technology industrial base. 2a. Greater efficiency (through agglomeration of US high technology industries). 3. Increased demand for Federal relief (Trade Act, import controls.)	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR IMPEDE	IMPACT ON SALES OF US MANUFACTURED PCS		IMPACTS RESULTING FROM FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
			DOMESTIC	FOREIGN		
10. U.S. government insists on "Buy American" plan for all its PC purchases or purchases by Federally-funded organizations.	1988 85-84 85-90 +90 NEVER	+1 Intense lobbying by US PC mfgrs, software houses.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Improvement of US balance of payments position. 2. Increased international competitiveness of US high technology industries. 3. Increased efficiency of Federal government operations.	
11. US establishes import quotas for PCs.	1988 85-84 85-90 +90 NEVER	+1 Intense protectionist lobbying by US firms, unions.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase in US balance of payments position. 2. Retaliatory action by other developed countries.	
12. US at least doubles duties on imported PCs, including those imported from foreign branches of US multinational firms.	1988 85-84 85-90 +90 NEVER	+1 Intense protectionist lobbying by US firms, unions.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase in US balance of payments position. 2. Retaliatory action by other developed countries.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES OF US MANUFACTURED PCS: DOMESTIC	IMPACT ON SALES OF US MANUFACTURED PCS: FOREIGN	IMPACTS RESULTING FROM FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
III. WORLD MARKET 13. US provides tax incentives for PC exporters.	1988 81-84 85-90 +90 NEVER	+1 Intense protectionist lobbying by US firms, unions.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Improved US balance of payments position. 2. Some return to US of overseas manufacturing operations of US multinationals. 3. 4.	
14. At least 1/3 of foreign production of PC hardware is from companies with at least 1/3 ownership by US interests.	1988 81-84 85-90 +90 NEVER	+1 Emphasis on use, sales of PCs by US-based multinationals. -1 Restrictive policies on US partipation by foreign governments.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased flight from US of PC manufacturing operations. 2. Increased foreign growth of PC mkt due to US marketing efforts. 3. No effect on US balance of payments.	
15. Federal gov't reorganizes to centralize formulation, control of trade policy, objective is to increase competitiveness in international market by assuring multilateral free trade agreements.	1988 81-84 85-90 +90 NEVER	+1 Strong pressure by Executive for centralization. -1 General resistance by scattered bureaucracies to centralization.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. 2 year stagnation, then improvement of US balance of payments. 2. Increased export activity by small US businesses. 3. General increase in level of international trade.	

POTENTIAL DEVELOPMENT	TIME OF OCCURRENCE	PRECURSOR CONDITIONS THAT COULD ENHANCE OR INHIBIT	IMPACT ON SALES OF US MANUFACTURED PCE		BENEFITS RESULTING FROM OCCURRENCE OF DEVELOPMENT	EXPERTISE
			DOMESTIC	FOREIGN		
16. US lifts restrictions, speeding licensing of PC exports.	1980 81-84 85-90 +90 NEVER	+1 Intense lobbying by PC industry.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increased export activity by small US businesses. 2. Improvement in US balance of payments.	
17. US creates special incentives for PC exports to LDCs.(e.g. loan guarantees, low interest loans from Ex-Im Bank).	1980 81-84 85-90 +90 NEVER	+1 Pressure from large US multinationals.	H M L 0 -L -M -H	H M L 0 -L -M -H	1. Increase rate of industrialization of LDCs. 2. Increase in economic tensions between DCs, 3rd world. 3. Increase in multinational participation in PC market.	

APPENDIX B:

EMPLOYMENT QUESTIONNAIRE

Please provide your name, so that we can send questionnaire results to you:

_____

PROBLEM STATEMENT

As part of an analysis of those possible effects of microcomputers that are relevant to public policy, we seek an estimate of some of the employment-related impacts. Because of your familiarity with employment conditions in this industry, we hope that you will take between fifteen and thirty minutes to complete this questionnaire. We will tabulate the results by industry and provide them to you, consistent with our confidentiality policies. Your answers will help us determine if the employment consequences of microcomputers should be left for private institutions and markets, or might merit further government concern.

Specifically, in this inquiry we are concerned with net employment changes, in several industries, which may be a consequence of the widespread use of microcomputers.

A microcomputer is a small, general purpose computer, frequently desk-top-size, which can be used for a variety of office functions, including text processing, accounting, electronic mail, and data base interaction. Some contemporary microcomputers duplicate or exceed the capabilities of popular, standalone minicomputers at a fraction (about half or less) of their price. An entire complement of the above functions including a letter quality printer, now typically costs less than $12,000.

We estimate that by 1990, all of the above computer capabilities will be available for less than $6,000. On the other hand, a $12,000 (1980 dollars) investment in 1990 will provide very extensive text processing, including sophisticated color graphics and extensive interactivity with other computers. These 1990 machines will include user training software and have "personalized" interfaces with their operators. In 1990 it is likely that many large corporations will use microcomputers extensively as components in distributed information processing systems.

The US Bureau of Labor Statistics uses the following gross categories for collecting and presenting data about the US labor force:

A. Professional, technical, and kindred
B. Managers, officials, and proprietors
C. Clerical and kindred
D. Sales
E. Craft and kindred
F. Operatives and kindred
G. Laborers
H. Service

We are using these same classifications in this inquiry.

CONFIDENTIALITY PLEDGE

Your candidness in responding to our questions may depend on your confidence that your estimates will neither be attributed to you or your company, nor even cited anonymously. We promise to retain your identity in our files in coded form only; to circulate and/or publish only aggregated or "grouped" responses to this questionnaire; and never to identify any respondents individually or to associate any company with any of the figures.

WHAT WE SEEK

In the questions that follow, we seek your unresearched, best estimate of several employment-related quantities. Your estimates of likely changes in employment levels hold greater significance for us than does the accuracy of the estimates of current employment levels. So, please devote your discretionary time to thinking about changes in employment levels, rather than to researching current employment figures. We recognize that the information you provide is personal, not official.

We shall ask a series of questions about current employment levels in your industry and in your firm, for several occupational categories defined above. We shall then ask you to forecast 1990 employment levels in your industry and in your firm for these categories. Next we ask that you estimate the percentage change in these categories, between 1980 and 1990, that will be attributable to automation. We ask you to further estimate the percentage change in these categories that will be attributable to microcomputers as defined above. Finally, we ask how any job displacement resulting from microcomputers might, and should, be handled.

YOUR INDUSTRY

Please consider your industry to be the _____ industry.

ESTIMATES OF 1980 EMPLOYMENT LEVELS IN INDUSTRY AND FIRM FOR SELECTED OCCUPATIONAL CATEGORIES

For each of the following occupational categories in column A, please estimate the current employment level in your INDUSTRY (column B) and in your FIRM (column D). Please also provide a range around each estimate within which, in your opinion, the chances are two out of three (2 out of 3) that the actual figure falls.

OCCUPATIONAL CATEGORY	YOUR INDUSTRY				YOUR FIRM			
(A)	(B)	(C)			(D)	(E)		
	1980 Employment (estimate)	The chances are 2 out of 3 that true figure lies between			1980 Employment (estimate)	The chances ar 2 out of 3 that true figure lies between		
(E.G.: Operatives, in Widgit Industry)	52,000	45,000	and	60,000	1,750	1,700	and	1,800
A			and				and	
B			and				and	
C			and				and	
D			and				and	
E			and				and	
F			and				and	
G			and				and	
H			and				and	

A. Professional, technical, and kindred.
B. Managers, officials, and proprietors.
C. Clerical and kindred.
D. Sales.
E. Craft and kindred.
F. Operatives and kindred.
G. Laborers.
H. Service.

FORECAST OF 1990 EMPLOYMENT LEVELS IN INDUSTRY AND FIRM FOR SELECTED OCCUPATIONAL CATEGORIES

For each of the following categories in column A, please forecast the future employment levels in your INDUSTRY (column B) and in your FIRM (column D). Please also provide a range around each forecast within which, in your opinion, the chances are two out of three (2 out of 3) that the actual figure falls.

OCCUPATIONAL CATEGORY	YOUR INDUSTRY			YOUR FIRM		
(A)	(B)	(C)		(D)	(E)	
	1990 Employment (forecast)	The chances are 2 out of 3 that true figure lies between		1990 Employment (forecast)	The chances are out of 3 that true figure lies between	
(E.G.: Operatives, in Widgit Industry)	45,000	40,000	and 50,000	1,900	1,700	and 2,000
A			and			and
B			and			and
C			and			and
D			and			and
E			and			and
F			and			and
G			and			and
H			and			and

A. Professional, technical, and kindred.
B. Managers, officials, and proprietors.
C. Clerical and kindred.
D. Sales.
E. Craft and kindred.
F. Operatives and kindred.
G. Laborers.
H. Service.

You have now estimated 1980 employment levels in your industry and your firm, and forecasted employment levels for 1990.

We would now like you to estimate the changes in employment levels that will be attributable to AUTOMATION, and to a subcategory of automation, MICROCOMPUTERS.

Changes in employment levels are the result of many factors, of which automation is only one. The impact of any specific factor may be in the same direction as the net trend, or in the opposite direction. (For example, the gross impact of government regulations may be an increase in employment, in an industry which suffers a net decrease in employment.) Likewise, the impact of microcomputers may be in the same or opposite direction as the impact of automation in general.

IMPACT OF AUTOMATION ON EMPLOYMENT
LEVELS IN YOUR INDUSTRY AND YOUR FIRM
1980 - 1990
SELECTED OCCUPATIONAL CATEGORIES

For each of the occupational categories in Column A, please estimate the percentage change in employment between 1980 and 1990 (1980-base) that will occur in your INDUSTRY (column B) and in your FIRM (column C).

(A) OCCUPATIONAL CATEGORY	(B) ESTIMATED % CHANGE IN EMPLOYMENT DUE TO AUTOMATION BETWEEN 1980 & 1990(80-BASE) FOR YOUR INDUSTRY.	(C) ESTIMATED % CHANGE IN EMPLOYMENT DUE TO AUTOMATION BETWEEN 1980 & 1990(80-BASE) FOR YOUR FIRM.
A:PROF,TECH.	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
B:MGMT.	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
C:CLERICAL	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
D:SALES	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
E:CRAFT	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
F:OPERATIVES	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
G:LABORERS	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)
H:SERVICE	____% INCREASE/DECREASE (circle one)	____% INCREASE/DECREASE (circle one)

IMPACT OF MICROCOMPUTERS ON EMPLOYMENT LEVELS
IN YOUR INDUSTRY AND IN YOUR FIRM
1980 - 1990
SELECTED OCCUPATIONAL CATEGORIES
PLEASE REFER TO PAGE 1, DEFINITIONS

For each of the occupational categories in column A, please estimate the percentage change in employment between 1980 and 1990 (1980 = base) that will occur in your INDUSTRY due to the use of microcomputers in your industry (column B) and in your FIRM due to the use of microcomputers in your firm (column C).

(A) OCCUPATIONAL CATEGORY	(B) ESTIMATED % CHANGE IN EMPLOYMENT BETWEEN 1980 AND 1990(80=BASE)IN YOUR INDUSTRY DUE TO USE OF MICROCOMPUTERS IN YOUR INDUSTRY.	(C) ESTIMATED % CHANGE IN EMPLOYMENT BETWEEN 1980 AND 1990(80=BASE)IN YOUR FIRM DUE TO USE OF MICROCOMPUTERS IN YOUR INDUSTRY.
A:PROF, TECH.	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
B:MGMT.	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
C:CLERICAL	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
D:SALES	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
E:CRAFT	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
F:OPERATIVES	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
G:LABORERS	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)
H:SERVICE	____ % INCREASE/DECREASE (circle one)	____ % INCREASE/DECREASE (circle one)

You have just estimated the change in employment levels, by occupational categories, in you industry between 1990 and 1990 that will be attributable to the use of the microcomputer in your industry. We would now like you to estimate how any gross decreases in employment due to this might be handled in your industry. Below is a list of four possible ways that job loss might be handled:

A. Termination.
B. Attrition.
C. Transfer within the firm without retraining.
D. Retraining and replacement at the firm's expense.
E. Other.

Please circle the letter at the right of each of the following statement that best represents the strategy you believe best completes the statement.

	TERMINATION	ATTRITION	TRANSFER	RETRAIN	OTHER
The strategy that will most commonly be followed in the industry for dealing with job losses attributable to the use of microcomputers in the industry is	A	B	C	D	E
The strategy that will least commonly be followed in the industry for dealing with job losses attributable to the use of microcomputers in the industry is	A	B	C	D	E
The strategy that I believe should be followed in the industry for dealing with job losses attributable to the use of microcomputers in the industry is	A	B	C	D	E

Please estimate the percentage of employees in your industry who currently use computers as part of their job responsibilities. "Use of computers" means direct interaction with a computer or computer terminal, even though this interaction is only occasional.

INDUSTRY	% CURRENTLY USING COMPUTERS	% USING COMPUTERS BY 1990
CATEGORY A: PROF, TECH.	_____ %	_____ %
CATEGORY B: MGMT.	_____ %	_____ %
CATEGORY C: CLERICAL	_____ %	_____ %
CATEGORY D: SALES	_____ %	_____ %
CATEGORY E: CRAFT	_____ %	_____ %
CATEGORY F: OPERATIVES	_____ %	_____ %
CATEGORY G: LABORERS	_____ %	_____ %
CATEGORY H: SERVICE	_____ %	_____ %

Please estimate your industry's growth over the next ten years:

	CURRENT LEVELS	CHANGE BY 1990, %	
SALES	_____ %	_____ %	INCREASE DECREASE (please circle one)
ASSETS	_____ %	_____ %	INCREASE DECREASE (please circle one)
EMPLOYMENT	_____ %	_____ %	INCREASE DECREASE (please circle one)

What government policies, existing or possible, might affect the way this INDUSTRY deals with the employment consequences of microcomputers?

What other factors might affect the estimates you have made here?